D3.4.3
Seasonal concentration and characterization of microplastics in the sand of the selected beaches of the 8 islands and in the surface waters off the selected beaches of 2 islands.

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Work Package	WP3
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This deliverable is the continuation of the deliverable *D3.4.4: Seasonal concentration and characterization of marine litter in selected beaches of 8 Mediterranean islands*. The reader should refer to the deliverable *D3.4.4* by following this link for further information on the general context about the marine litter and the microplastics in particular in the Mediterranean Sea.

I. Main objectives of the BLUEISLANDS project

One of the aims of the BLUEISLANDS project is to properly identify, address and mitigate the seasonal variation of waste generated on Mediterranean islands as an effect of tourism by assessing, amongst other, the seasonal dynamics of marine litter, with a special attention paid to both the micro- (<5mm) and macroplastics (>5mm, including mesoplastics: 0.5cm – 2.5cm), in highly touristic coastal areas (i.e. beaches). The aim is to propose strategies to reduce the amount of litter related to touristic and recreational activities on beaches and to reduce its negative effects on the coastal environment. A total of 8 islands from the Mediterranean Sea (Mallorca, Sicily, Rab (Croatia), Malta, Crete, Mykonos, Rhodes and Cyprus) are involved. For each of these islands, 3 specific beaches have been periodically monitored to assess the seasonal variation of litter as an effect of tourism.

II. Sampling strategy and methodology

In order to assess the seasonal variation of microplastics concentrations on sandy beaches as an effect of tourism on Mediterranean islands, 24 beaches (3 per island) have been monitored for microplastics concentrations during both the low and high seasons. An exhaustive guideline regarding the implementation of these surveys has been provided (see deliverable D3.1.2: *Handbook for common approaches and methodologies – Field sampling and study measuring micro- and macroplastics input in partners coastal regions*). Briefly, for each selected site, a fixed 100m portion of beach was defined for the marine litter surveys (see Deliverable *D3.4.4: Seasonal concentration and characterization of marine litter in selected beaches of 8 Mediterranean islands*). This is on this portion that sand samples were collected (see below): 5 samples per survey and 4 surveys for each beach (2 during the low season and 2 during the high season, in 2017). In parallel to the surveys performed on the beaches, surface water off the selected beaches of Sicily and Cyprus was collected as well for further analysis. The surveys for the surface water were performed in June, August, September and November 2018.

1. Methodology: field work

For each island, 3 different beaches were selected and monitored for microplastics concentrations. The 3 beaches were selected in order to include 1 impact sites where tourists represent most of the visitors to the beach and 2 control sites including a beach where locals represent most of the visitors and a remote/preserved beach where the frequentation of both tourists and locals is low. For more details please see Deliverable *D3.4.4: Seasonal concentration and characterization of marine litter in selected beaches of 8 Mediterranean islands*.

a) Sand sampling

The survey for the micro-plastics on the beaches consisted of the collection of 5 samples of sand on the fixed 100m portion of each beach (**Fig. 1**). The sampling was done during the marine litter surveys.

Each sample consists of ±1 liter of sand. Among the 5 samples, 3 were collected in the middle of the beach (**Fig. 1a**) and 2 were collected in the high water mark (**Fig. 1a**). The samples were stored in clean glass jars with specific labelling (including the island, the name of the beach, the reference of the sample and the coordinates of the sampling site). Briefly, for each sample, a quadrat of 20x20cm (metal or wood) was put on the ground and the sand was removed from the 2 – 3 upper cm using a metal trowel (or table spoon) and stored in a clean glass jar. It was strongly recommended to wear cotton clothing to reduce risk of contamination from micro-plastic fibers from surveyor's clothing. Once collected, the samples were sent to the laboratory, in Barcelona (Spain) for further analysis.

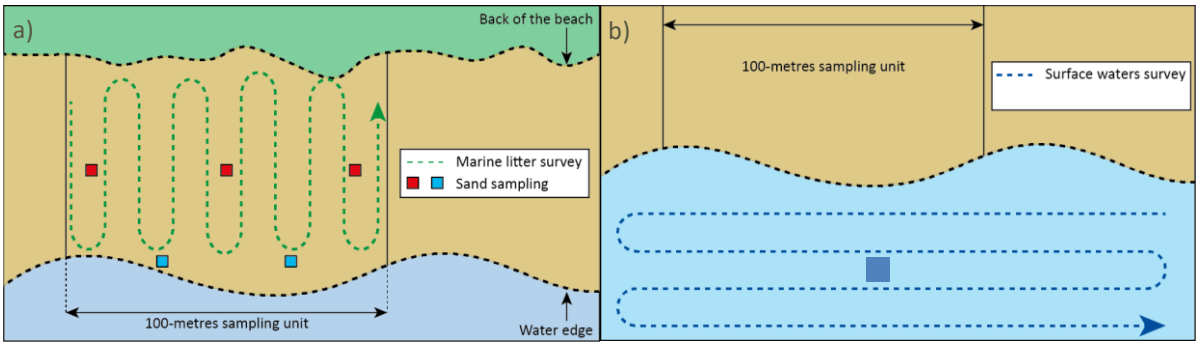

Figure 1: *field work implementation. a) Drawing showing the disposition of the collecting sites for the micro-plastics on the fixed 100m portion of beach for the marine litter surveys. b) Drawing showing the disposition of the survey for surface waters sampling (not to scale) off the selected beaches.*

b) Surface water sampling

The surface waters off the selected beach (**Fig. 1b**) was sampled using a micrpoplastic net with a mesh size of less than 100µm (0.1mm) dragged by the boat. The net was deployed along one or more transects parallel to the selected beach. The transect covered the total length of the beach and not only the fixed 100m portion. The surface waters was sampled for 30 minutes at a speed of 2-3 knots representing a distance of ~1.8 to ~2.9 km. The number of transects depended of the total length of the selected beach: if the length of the beach was more than 2km, then only one transect was needed. If the total length of the beach was less than 2 km at least 2 transects were considered. In any case for each transect, the initial and final coordinates as well as the deploying time were reported on a table sheet. To ensure a good sampling it was necessary to comply with the following steps:

- Report the coordinates of the starting point and the time
- Deploy the net from the side of the vessel to avoid collecting water affected by turbulence
- Move in one straight direction at 2-3 kt for 30 min
- Report the coordinates of the ending point and the time
- Rinse the net thoroughly from the outside and from top to bottom to concentrate the particles with sea water
- Safely remove the cod end of the net
- Rinse thoroughly the cod end from the outside
- Sieve the water collected with the same mesh size as the net
- Pour the rest of the sample through the sieve until no particles remain in the cod end
- With a funnel, rinse the sieve into a glass jar with 70% ethanol
- Close and label the glass jar.

The samples were shipped to Barcelona (Spain), for further analysis.

2. Methodology: laboratory analysis

a) Microplastics extraction

To avoid any contamination from airborne particles, all the samples were processed in a clean environment (**Fig. 2**) at the ICTA-UAB, Barcelona (Spain).

For sand beach samples, the microplastics were extracted using the methodology developed by Thompson et al. (2004) with some modifications (**Fig. 2**). For a given sample, about 100g (dry weight) of sediments and 250ml of concentrated NaCl solution were added into a pre-rinsed 2L glass beaker. If the sample was wet, it was left to dry at 50°C on a hot plate before adding the NaCL solution. The mixture was stirred for 20 min at 200rpm. The solution was left to settle for two hours. The supernatant solution was piped out into a clean glass beaker and vacuum filtered using a glassfibre filter (GF/F; 47mm ø, 0.7 µm). The walls of the funnel attached to the vacuum system were rinsed twice with pure analytical grade water (MilliQ®) in order to remove the particles that might remain attached. The fibre glass filters were stored in Petri dishes and dried at 40ºC overnight. The extraction was performed five consecutive times to test the efficiency of the methods. After every extraction, the walls of the beaker containing the sample were rinsed with concentrated NaCl solution, once again, to avoid the lost and underestimation of some particles that might remain attached to the walls.

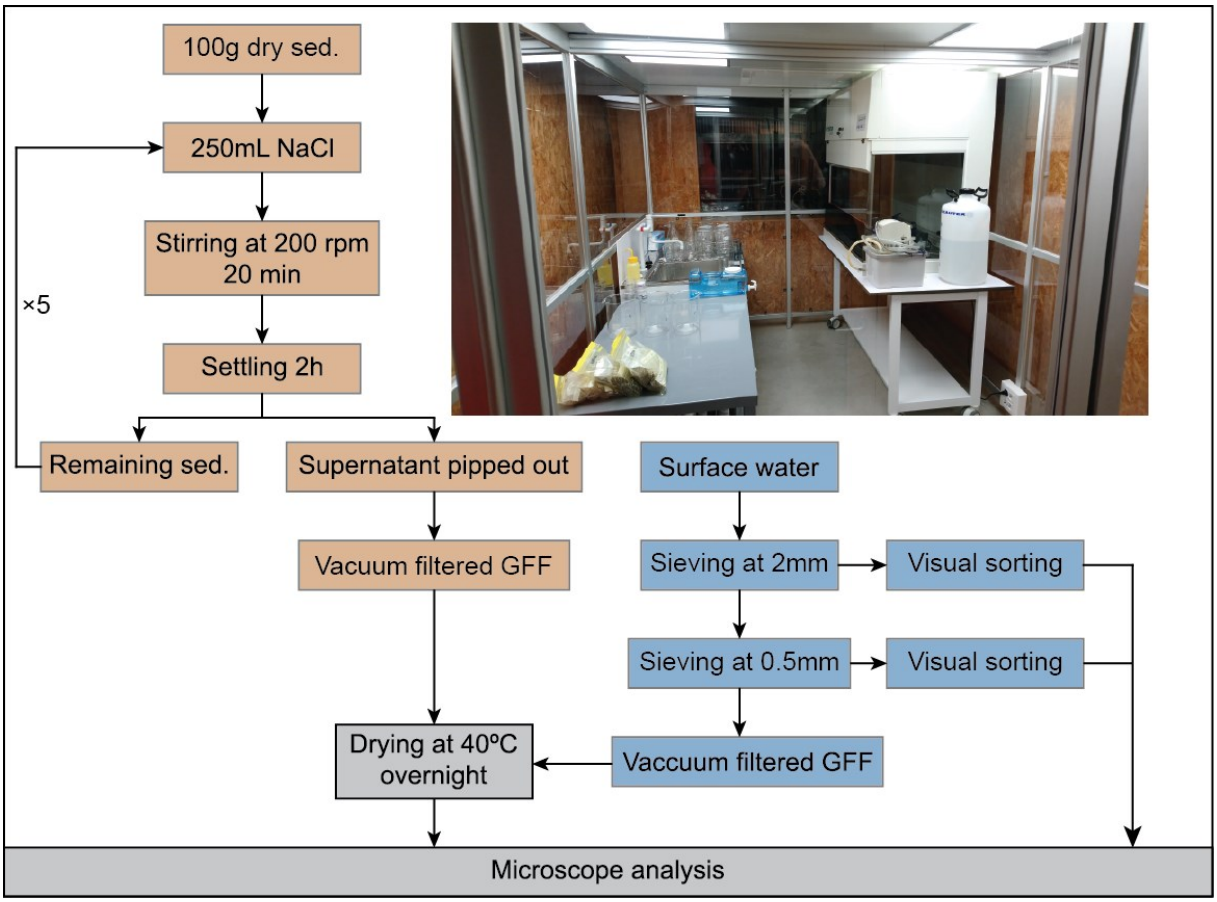

Figure 2: *microplastics extraction method. Top right: picture of the clean laboratory where the samples were processed. Brown boxes refer to the sand samples. Blue boxes refer to the surface water samples.*

The surface water samples were first sieved at 2mm to remove the biggest particles (**Fig. 2**). In this fraction, the microplastics (<5mm) were visually sorted and stored in petri dishes. The remaining fraction (<2mm) was sieved at 0.5mm. Again the microplastics were visually sorted and stored on petri dishes. Finally the smallest fraction (<0.5mm) was vacuum filtered (GF/F; 47mm ø, 0.7 µm) in the laboratory. In order to remove some particles that might remain attached to the walls of the glass container, they were rinsed twice with a squirt bottle containing MilliQ®, and also filtered as part of the sample. The fibre glass filters were dried at 40ºC overnight and stored in Petri dishes.

b) Microplastics characterization

All the particles collected (from the sieving for the surface water samples and on the filters) were processed under dissecting microscope (Leica Z16 APO, magnification 7.1-115×). For the filters, the entire surface was observed from the top left to the bottom right to avoid double-counting. Visual identification of plastic particles followed the criteria of the Guide for identification Microplastics-MERI (Marine & Environmental Research Institute). Thus, particles identified as microplastics were counted, photographed and classified under type, size and colour categories. The categories of microplastic types considered were: microbead, fragment, foam, fibre, film/foil and aggregation of fibres (**Fig. 3**). For the size, the maximum length of particles was measured using the software ImageJ (Schneider et al., 2012)and grouped under eight maximal length classes (<50; 50-100; 100-200; 200-500; 500-1000; 1000-2000; 2000-3000; >3000 µm) (adapted from Song et al., 2015). Finally, particles were sorted under color properties considering four categories: transparent (transparent and translucent), black, white and color (light blue, dark blue, red, yellow, purple, grey, etc.).

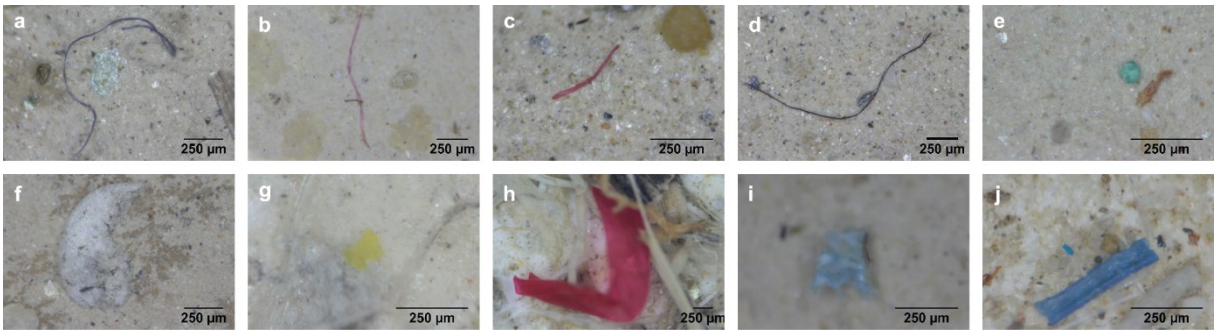

Figure 3: *types of microplastics. a-d) Fibres. e) Microbead. f) Foam. g-h) Films. i) Fragment. j) Film and fragment. Pictures: Laura Simon.*

The results on color and the type of each particles are presented in the main core of this report. However, the data regarding the size distribution of the particles are only presented in the Part C: General discussion at the Mediterranean Scale. Indeed, it was not possible to measure all the particles collected from each beach. Then the specific size distribution for each beach is presented but not discussed in the Part F: Appendix.

c) Microplastic extraction efficiency from sand samples

Five sequential density separations were performed on 51 beach samples to test the efficiency of the methodology to recover microplastics. The results showed a clear decrease in the number of particles retrieved after each density separation. It is fairly possible that not all the particles were recovered from the sample even after the fifth density separation (**Fig. 4**). The recovery rate at the first extraction

represented an average of 35.2% (±13%) compared to the total after five separations. From the consecutives extractions, the recovery rate increases to 59.4% at the second, to 75.3% at the third and 87.9% at the fourth extraction.

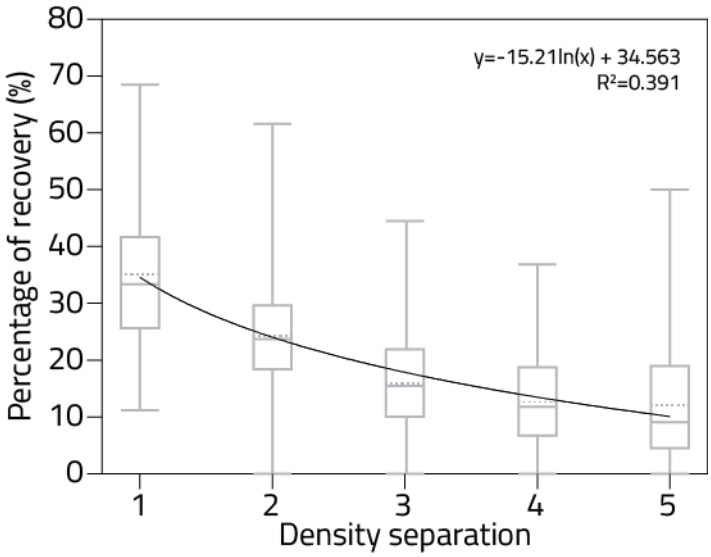

Figure 4: *microplastics recovery in sand samples after 5 consecutive density separations.*

III. References

Song, Y.K., Hong, S.H., Jang, M., Han, G.M., Rani, M., Lee, J., Shim, W.J., 2015. A comparison of microscopic and spectroscopic identification methods for analysis of microplastics in environmental samples. Mar. Pollut. Bull. 93, 202–209. https://doi.org/10.1016/j.marpolbul.2015.01.015

Thompson, R.C., Olsen, Y., Mitchell, R.P., Davis, A., Rowland, S.J., John, A.W.G., McGonigle, D., Russell, A.E., 2004. Lost at sea: where is all the plastic? *Science*, 304, 838. doi:10.1126/science.1094559

Part D: General Results at the Mediterranean Scale

In this section, the results obtained from the 79 campaigns of sampling performed on the 8 involved islands (Mallorca, Sicily, Rab, Malta, Crete, Mykonos, Rhodes and Cyprus, see **Fig. 5**) are summarized at the Mediterranean scale. The results will be presented by considering 1) the 8 islands, without considering the type of beach, 2) the 8 touristic beaches, 3) the 8 beaches mainly used by locals and 4) the 8 remote beaches.

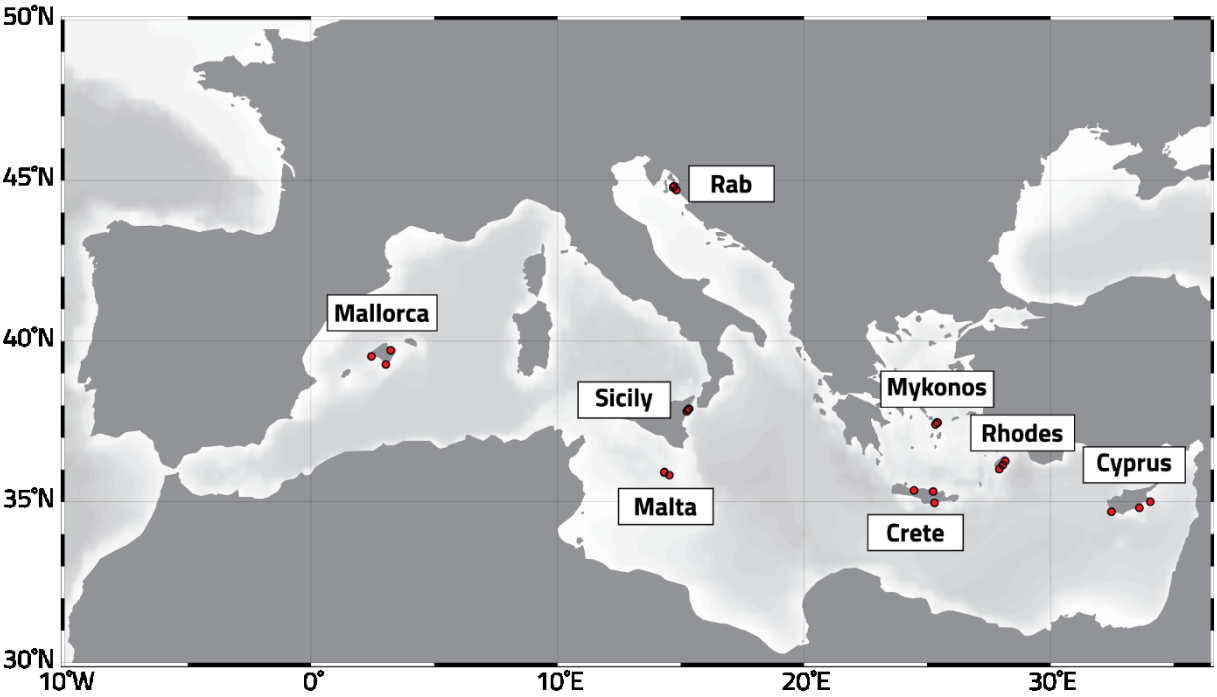

Figure 5: *location map of the 8 islands involved in the monitoring of the microplastics. The selected sites are shown by red spots.*

I. Results at the Mediterranean Scale

1. Seasonality of the microplastics

The 24 selected beaches were sampled for microplastics concentrations in February (9 campaigns), March (9 campaigns), May (3 campaigns), June (21 campaigns), August (6 campaigns), September (11 campaigns) and November (20 campaigns) of 2017 (**Fig. 6a**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in February (177.6 MPs/kg of dry sand ± 82.6 MPs/kg), while the highest averaged concentration is observed in June (1579.8 MPs/kg of dry sand ± 2849.1 MPs/kg) (**Fig. 6a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in February (184.4 MPs/kg of dry sand ± 106.2 MPs/kg) and the highest in August (853 MPs/kg of dry sand ± 1166.9 MPs/kg) (**Fig. 6a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in February (190.6 MPs/kg of dry sand ± 82.5 MPs/kg) and the highest in June (989.9 MPs/kg of dry sand ± 1383.2 MPs/kg) (**Fig. 6a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to the 8 selected islands: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 6a**). During the low season the average concentrations is of 485.7 MPs/kg of dry sand (± 89.9 MPs/kg) for the middle of the beach, of 340.3 MPs/kg of dry sand (± 139 MPs/kg)

for the high water mark and of 318.7 MPs/kg of dry sand (± 110.2 MPs/kg) for the average (**Fig. 6b**). During the high season the average concentrations is of 1080.9 MPs/kg of dry sand (± 344.2 MPs/kg) for the middle of the beach, of 477.1 MPs/kg of dry sand (± 243.1 MPs/kg) for the high water mark and of 742.7 MPs/kg of dry sand (± 217.9 MPs/kg) for the average (**Fig. 6b**). The concentrations are always higher during the high season, no matter the origin of the sample. Finally an average increase of +133.1% of the concentrations of microplastics is observed from the low to the high season (**Fig. 6b**).

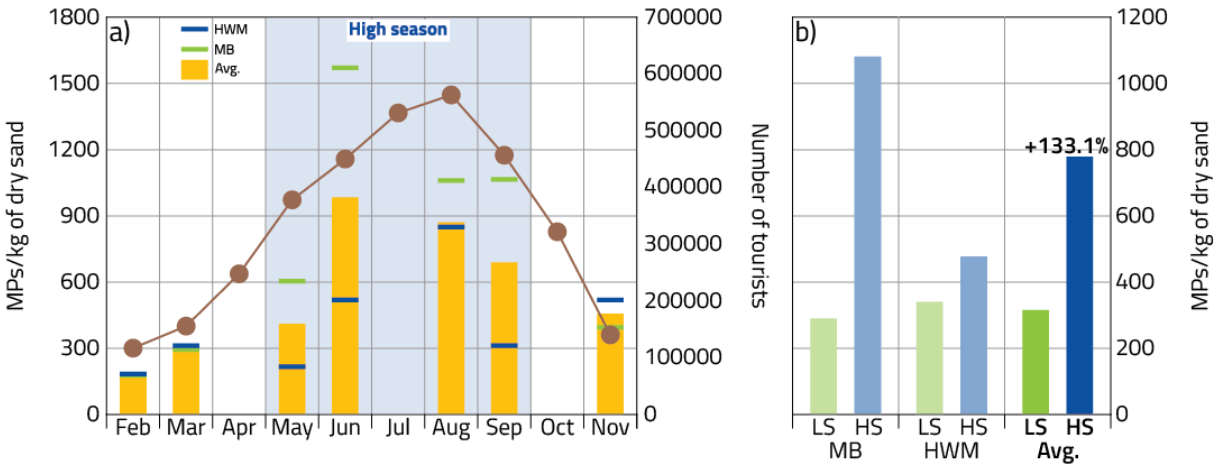

Figure 6: *average concentrations of microplastics for the 24 selected beaches. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[1] for the 8 islands. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

2. Types of microplastics

On average the microplastics extracted from the sand of the 24 selected beaches are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=65.5% ±16.7%; LS=67.4% and HS=63.1%), followed by the fragments (Avg=25.9% ±14.3%; LS=21.7% and HS=29.4%), the films (Avg=4.4% ±4.1%; LS=4.7% and HS=5%), the foam (Avg=3.1% ±5%; LS=4.4% and HS=1.9%), the aggregates (Avg=0.7% ±2.5%; LS=1.3% and HS=0.2%), the microbeads (Avg=0.2% ±0.8%; LS=0.4% and HS=0.1%) and the particles not identified but suspected to be microplastics (Avg=0.2% ±0.7%; LS=0.1% and HS=0.3%). The proportion of fibers and fragments is higher during the high season compared to the low season (**Fig. 7**).

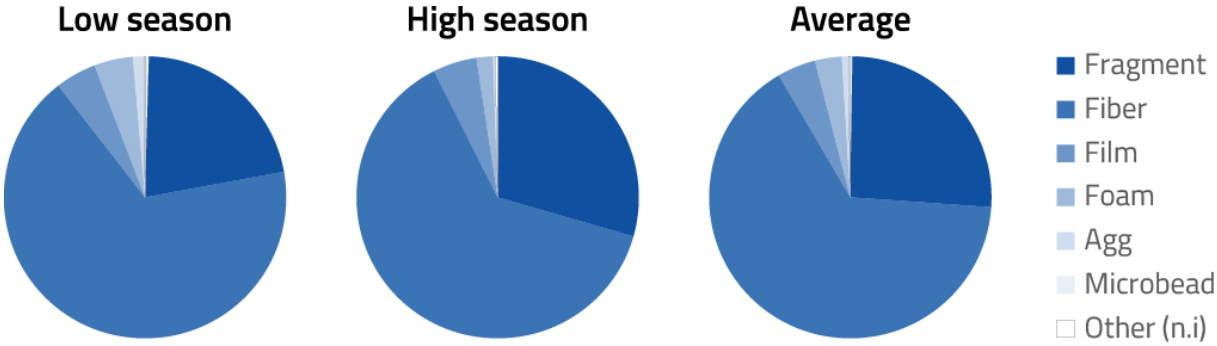

Figure 7: *comparison of the types of microplastics collected in the sand samples of the 24 selected beaches. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

[1] Data source: monthly average number of tourists welcomed to the 8 islands. See the *Part D Detailed results for each island*.

3. Colors of microplastics

On average the microplastics extracted from the sand of the 24 selected beaches are dominated by colored particles (Avg=66.4% ±5.9%; LS=61.3% and HS=69.7%), followed by the transparent particles (Avg=16.2% ±4.6%; LS=12.9% and HS=19.5%), the black particles (Avg=12.2% ±8.2%; LS=18.9% and HS=7.4%) and the white particles (Avg=5.2% ±2.3%; LS=6.8% and HS=3.5%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 8**).

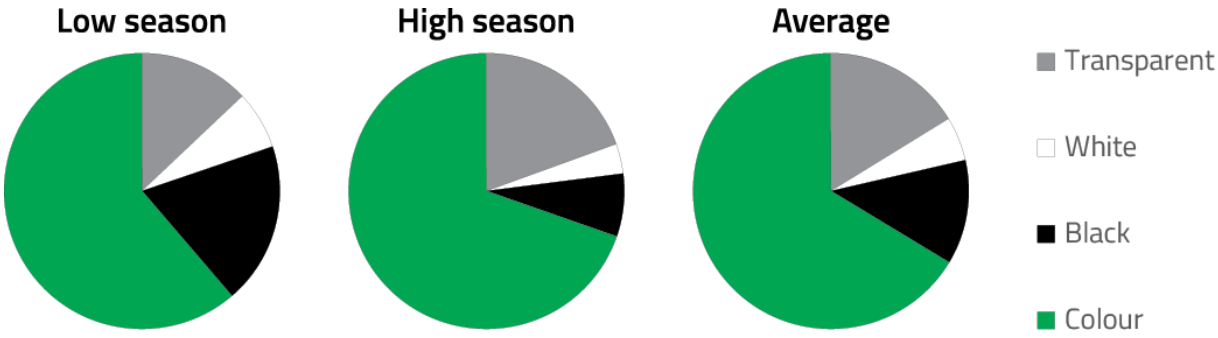

Figure 8: *comparison of the colors of microplastics collected in the sand samples of the 24 selected beaches. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

4. Size distribution of microplastics

The size distribution of the microplastics from the 24 selected beaches shows a clear unimodal distribution centered on the 0.2 – 0.5mm class (**Fig. 9**). This class represents 25.2% of all the particles collected. The second most frequent class is the 0.5 – 1.0mm (23.2%) followed by the 1.0 – 2.0mm (16.5%). Taken together these 3 classes represent 64.9% of all the microplastics collected.

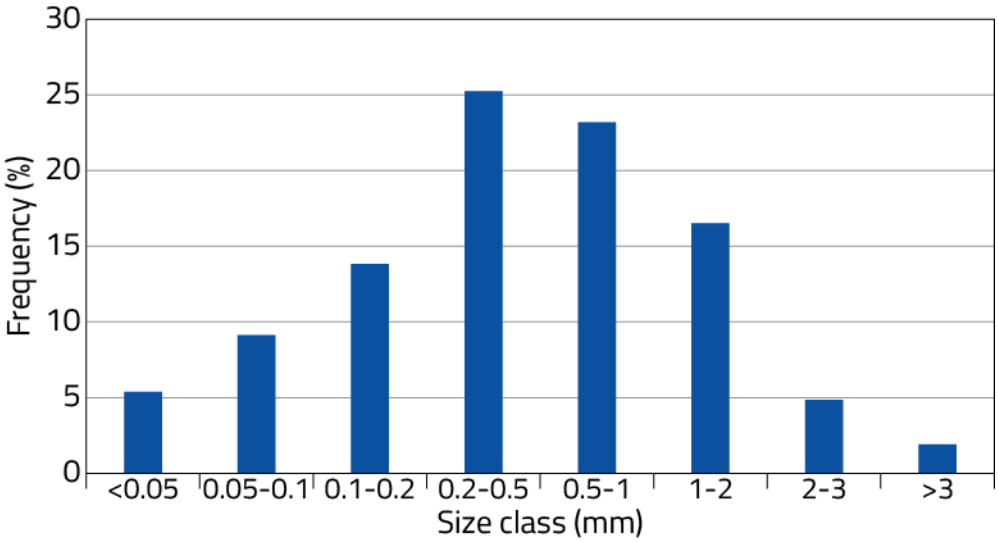

Figure 9: *size distribution of the microplastics collected on the sand samples of the 24 selected beaches.*

II. Results for the touristic beaches

1. Seasonality of the microplastics

The 8 selected touristic beaches were sampled for microplastics concentrations in February (3 campaigns), March (3 campaigns), May (1 campaigns), June (7 campaigns), August (2 campaigns), September (3 campaigns) and November (6 campaigns) of 2017 (**Fig. 10a**). The lowest averaged

concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in February (230.8 MPs/kg of dry sand ± 101.9 MPs/kg), while the highest averaged concentration is observed in June (2044.1 MPs/kg of dry sand ± 1320.2 MPs/kg) (**Fig. 10a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in May (152.6 MPs/kg of dry sand ± 19.9 MPs/kg) and the highest in August (2203.6 MPs/kg of dry sand ± 1151.5 MPs/kg) (**Fig. 10a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in February (260.6 MPs/kg of dry sand ± 96.3 MPs/kg) and the highest in August (2100.3 MPs/kg of dry sand ± 1070 MPs/kg) (**Fig. 10a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to the 8 selected islands: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 10a**). During the low season the average concentrations is of 547.2 MPs/kg of dry sand (± 297.7 MPs/kg) for the middle of the beach, of 647.4 MPs/kg of dry sand (± 429.9 MPs/kg) for the high water mark and of 603.9 MPs/kg of dry sand (± 356.5 MPs/kg) for the average (**Fig. 10b**). During the high season the average concentrations is of 1602.8 MPs/kg of dry sand (± 606.4 MPs/kg) for the middle of the beach, of 867.8 MPs/kg of dry sand (± 805.5 MPs/kg) for the high water mark and of 1235.3 MPs/kg of dry sand (± 628.3 MPs/kg) for the average (**Fig. 10b**). The concentrations are always higher during the high season, no matter the origin of the sample. Finally an average increase of +104.6% of the concentrations of microplastics is observed from the low to the high season (**Fig. 10b**).

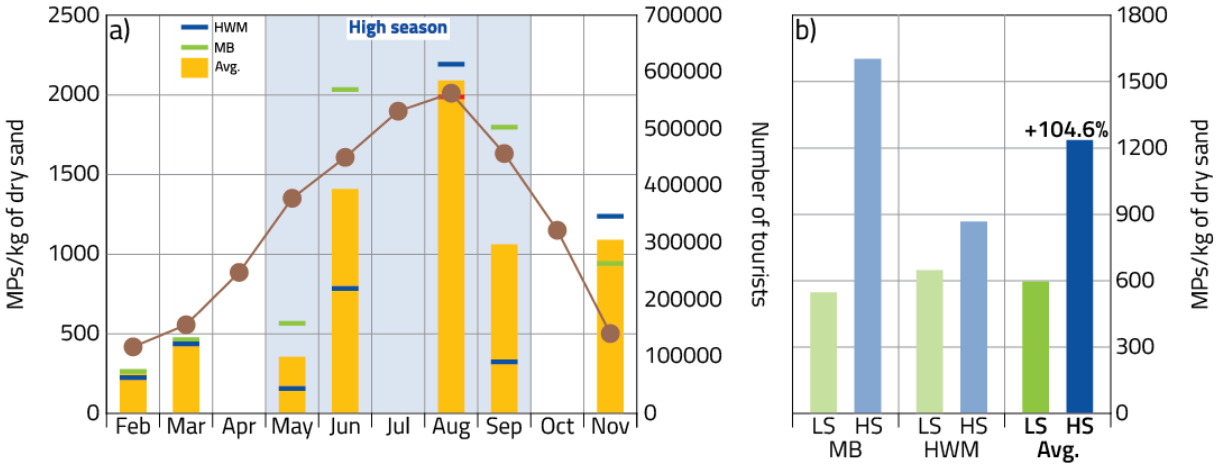

Figure 10: *average concentrations of microplastics for the 8 touristic beaches. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[2] for the 8 islands. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

2. Types of microplastics

On average the microplastics extracted from the sand of the 8 selected touristic beaches are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=62.4% ±18.8%; LS=65.7% and HS=58.3%), followed by the fragments (Avg=30.2% ±12.1%; LS=24.7% and HS=33.2%), the films (Avg=4.1% ±3.8%; LS=5.6% and HS=5.3%), the foam (Avg=2.8% ±3.8%; LS=3.5% and HS=2.4%),

[2] Data source: monthly average number of tourists welcomed to the 8 islands. See the *Part D Detailed results for each island*.

the aggregates (Avg=0.3% ±0.3%; LS=0.2% and HS=0.4%), the microbeads (Avg=0.1% ±0.1%; LS=0% and HS=0.2%) and the particles not identified but suspected to be microplastics (Avg=0.2% ±0.4%; LS=0.3% and HS=0.1%). The proportion of fibers and fragments is higher during the high season compared to the low season (**Fig. 11**).

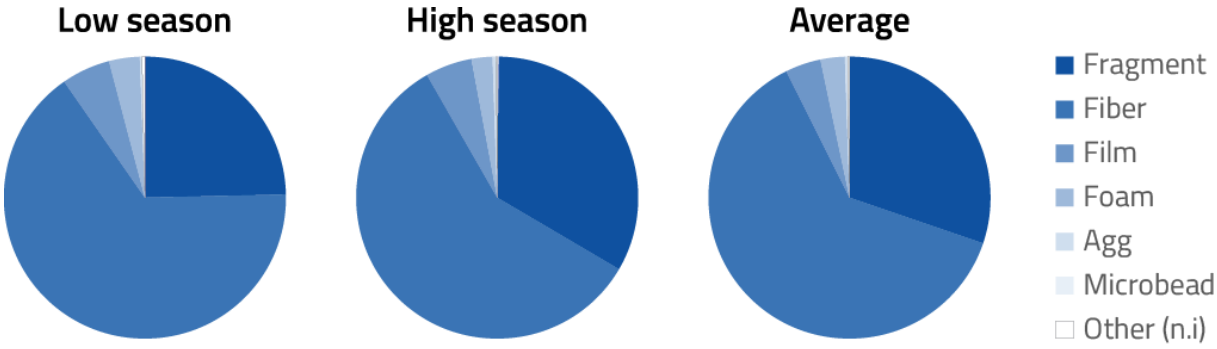

Figure 11: *comparison of the types of microplastics collected in the sand samples of the 8 touristic beaches. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

3. Colors of microplastics

On average the microplastics extracted from the sand of the 8 selected touristic beaches are dominated by colored particles (Avg=70.1% ±8%; LS=64.3% and HS=75.7%), followed by the transparent particles (Avg=13.2% ±1.2%; LS=14.3% and HS=12.6%), the black particles (Avg=10.7% ±7.5%; LS=16.8% and HS=6.2%) and the white particles (Avg=6% ±0.7%; LS=4.5% and HS=5.5%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 12**).

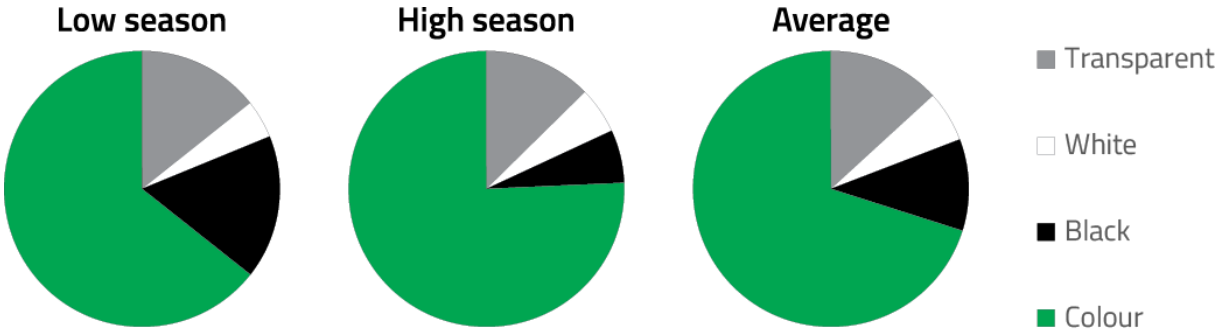

Figure 12: *comparison of the colors of microplastics collected in the sand samples of the 8 touristic beaches. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

4. Size distribution of microplastics

The size distribution of the microplastics from the 8 selected touristic beaches shows a clear unimodal distribution centered on the 0.2 – 0.5mm class (**Fig. 13**). This class represents 28.2% of all the particles collected. The second most frequent class is the 0.5 – 1.0mm (24.9%) followed by the 1.0 – 2.0mm (12.6%). Taken together these 3 classes represent 65.7% of all the microplastics collected.

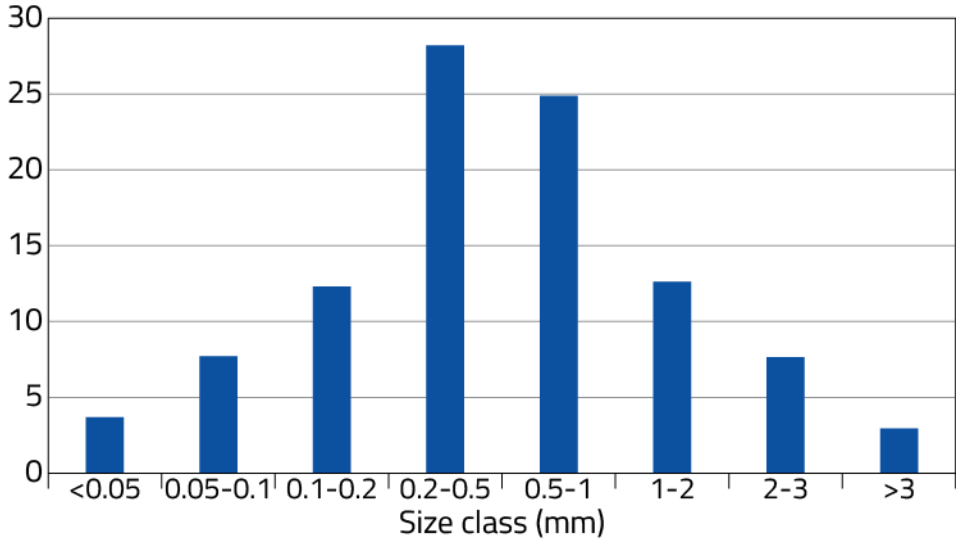

Figure 13: *size distribution of the microplastics collected on the sand samples of the 8 touristic beaches.*

III. Results for the beaches mainly used by locals

1. Seasonality of the microplastics

The 8 selected beaches mainly used by locals were sampled for microplastics concentrations in February (3 campaigns), March (3 campaigns), May (1 campaigns), June (7 campaigns), August (2 campaigns), September (3 campaigns) and November (6 campaigns) of 2017 (**Fig. 14**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in February (135.6 MPs/kg of dry sand ± 36.4 MPs/kg), while the highest averaged concentration is observed in June (2334.5 MPs/kg of dry sand ± 4593.5 MPs/kg) (**Fig. 14a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in June (154.1 MPs/kg of dry sand ± 121.6 MPs/kg) and the highest in September (495.3 MPs/kg of dry sand ± 519.6 MPs/kg) (**Fig. 14a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in February (153.8 MPs/kg of dry sand ± 34.3 MPs/kg) and the highest in June (1101.9 MPs/kg of dry sand ± 2142.5 MPs/kg) (**Fig. 14a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to the 8 selected islands: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 14a**). During the low season the average concentrations is of 177.4 MPs/kg of dry sand (± 33.6 MPs/kg) for the middle of the beach, of 194.3 MPs/kg of dry sand (± 20.6 MPs/kg) for the high water mark and of 185.7 MPs/kg of dry sand (± 27 MPs/kg) for the average (**Fig. 14b**). During the high season the average concentrations is of 992 MPs/kg of dry sand (± 783.6 MPs/kg) for the middle of the beach, of 304.8 MPs/kg of dry sand (± 128.9 MPs/kg) for the high water mark and of 612.8 MPs/kg of dry sand (± 296.3 MPs/kg) for the average (**Fig. 14b**). The concentrations are always higher during the high season, no matter the origin of the sample. Finally an average increase of +230% of the concentrations of microplastics is observed from the low to the high season (**Fig. 14b**).

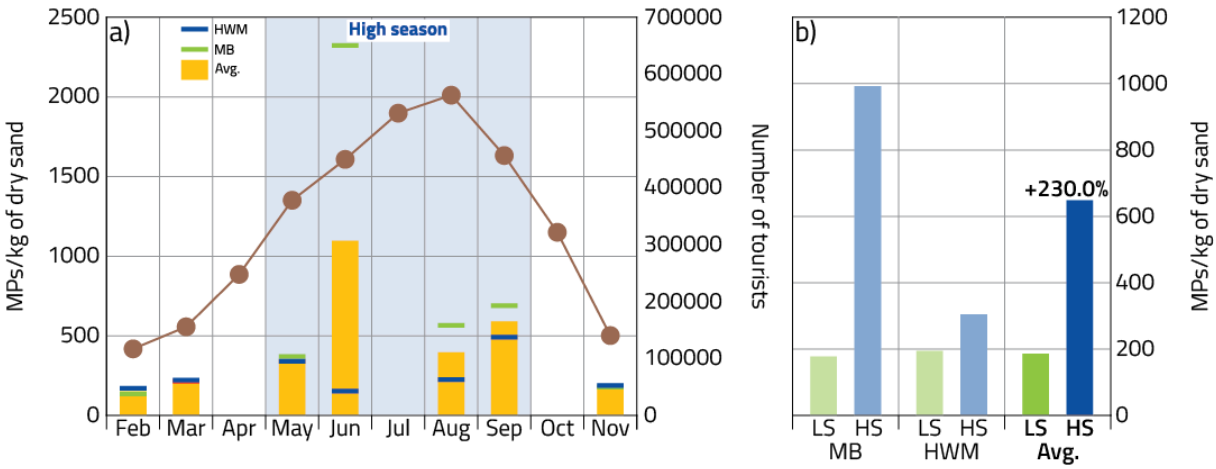

Figure 14: *average concentrations of microplastics for the 8 beaches mainly used by locals. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[3] for the 8 islands. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

2. Types of microplastics

On average the microplastics extracted from the sand of the 8 selected beaches mainly used by locals are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=65.4% ±18.4%; LS=64.9% and HS=65.5%), followed by the fragments (Avg=23.2% ±13.4%; LS=20.1% and HS=27.5%), the films (Avg=5.8% ±5.1%; LS=5.1% and HS=6.1%), the foam (Avg=5.1% ±7.6%; LS=9.4% and HS=0.6%), the aggregates (Avg=0.3% ±0.4%; LS=0.2% and HS=0.3%), the microbeads (Avg=0.2% ±0.4%; LS=0.3% and HS=0%) and the particles not identified but suspected to be microplastics (Avg=0% ±0%; LS=0% and HS=0%). The proportion of fibers and fragments is higher during the high season compared to the low season (**Fig. 15**).

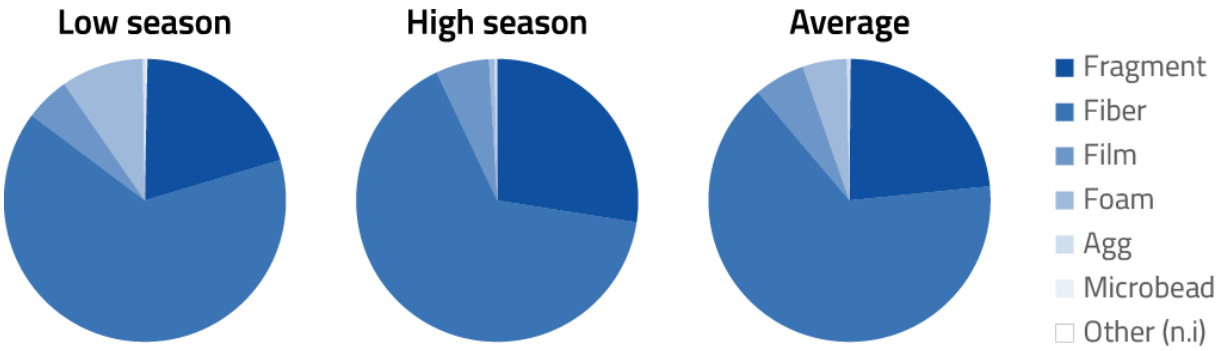

Figure 15: *comparison of the types of microplastics collected in the sand samples of the 8 beaches mainly used by locals. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

3. Colors of microplastics

On average the microplastics extracted from the sand of the 8 beaches mainly used by locals are dominated by colored particles (Avg=64.5% ±6.6%; LS=58.2% and HS=67.6%), followed by the transparent particles (Avg=18.9% ±4.7%; LS=16.1% and HS=22.7%), the black particles (Avg=10.7%

[3] Data source: monthly average number of tourists welcomed to the 8 islands. See the *Part D Detailed results for each island*.

±3.5%; LS=13.5% and HS=8.6%) and the white particles (Avg=5.9% ±7.8%; LS=12.1% and HS=1.1%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 16**).

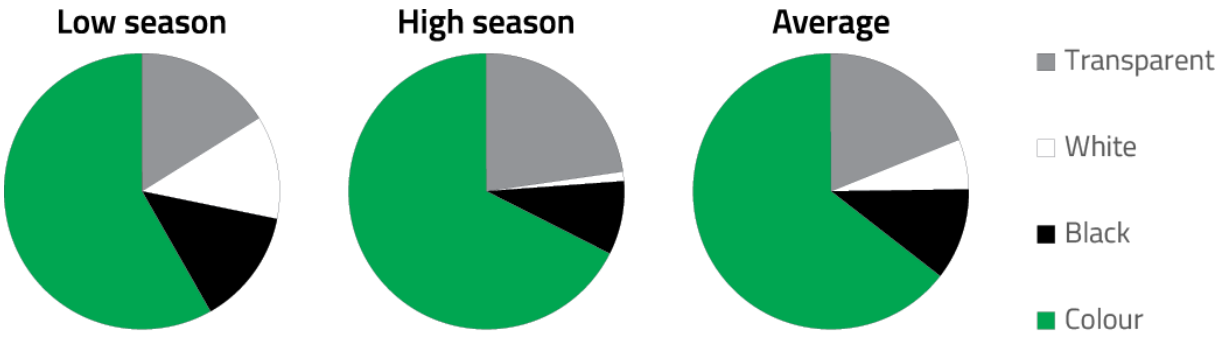

Figure 16: *comparison of the colors of microplastics collected in the sand samples of the 8 beaches mainly used by locals. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

4. Size distribution of microplastics

The size distribution of the microplastics from the 8 selected beaches mainly used by locals does not show a clear unimodal distribution (**Fig. 17**). The class with the highest frequency is the 1.0 – 2.0mm (24.6%) followed by the 0.2 – 0.5mm (21.2%), the 0.5 – 1.0 mm (19.3%) and the 0.1 – 0.2mm (19.2 %). Taken together these 4 classes represent 84.3% of all the microplastics collected.

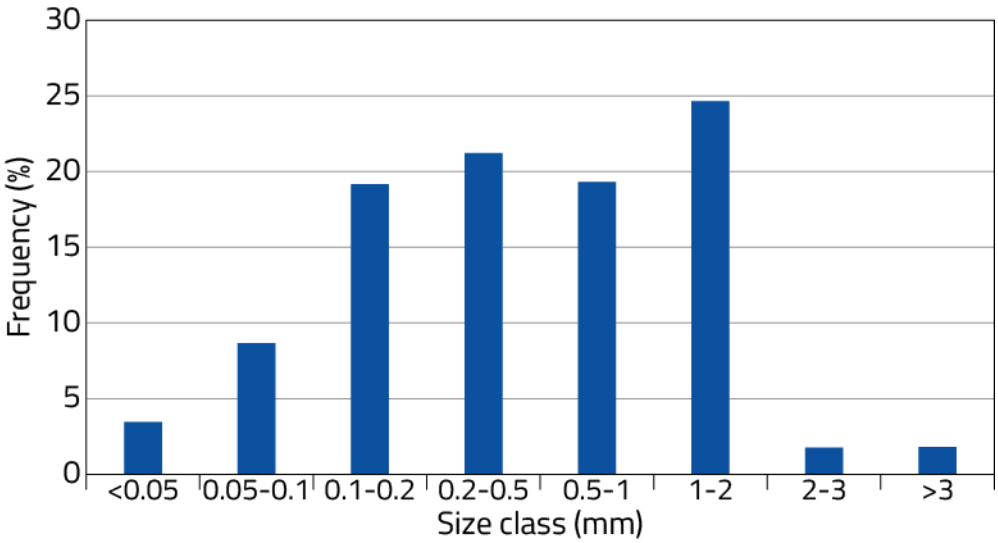

Figure 17: *size distribution of the microplastics collected on the sand samples of the 8 beaches mainly used by locals.*

IV. Results for the remote beaches

1. Seasonality of the microplastics

The 8 selected remote beaches were sampled for microplastics concentrations in February (3 campaigns), March (3 campaigns), May (1 campaigns), June (7 campaigns), August (2 campaigns), September (3 campaigns) and November (6 campaigns) of 2017 (**Fig. 18**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in November (36.5 MPs/kg of dry sand ± 25 MPs/kg), while the highest averaged concentration is observed in May (886.1 MPs/kg of dry sand ± 115.5 MPs/kg) (**Fig. 18a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in September (57.1 MPs/kg of dry sand ± 22.9 MPs/kg) and the highest in June (622.9

MPs/kg of dry sand ± 691.5 MPs/kg) (**Fig. 18a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in November (60.9 MPs/kg of dry sand ± 47.3 MPs/kg) and the highest in May (524.3 MPs/kg of dry sand ± 68.3 MPs/kg) (**Fig. 18a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to the 8 selected islands: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 18a**). During the low season the average concentrations is of 137.0 MPs/kg of dry sand (± 73.1 MPs/kg) for the middle of the beach, of 169.4 MPs/kg of dry sand (± 78.8 MPs/kg) for the high water mark and of 153.2 MPs/kg of dry sand (± 73.8 MPs/kg) for the average (**Fig. 18b**). During the high season the average concentrations is of 490.4 MPs/kg of dry sand (± 271.5 MPs/kg) for the middle of the beach, of 242.6 MPs/kg of dry sand (± 222.8 MPs/kg) for the high water mark and of 357.1 MPs/kg of dry sand (± 150.3 MPs/kg) for the average (**Fig. 18b**). The concentrations are always higher during the high season, no matter the origin of the sample. Finally an average increase of +133.1% of the concentrations of microplastics is observed from the low to the high season (**Fig. 18b**).

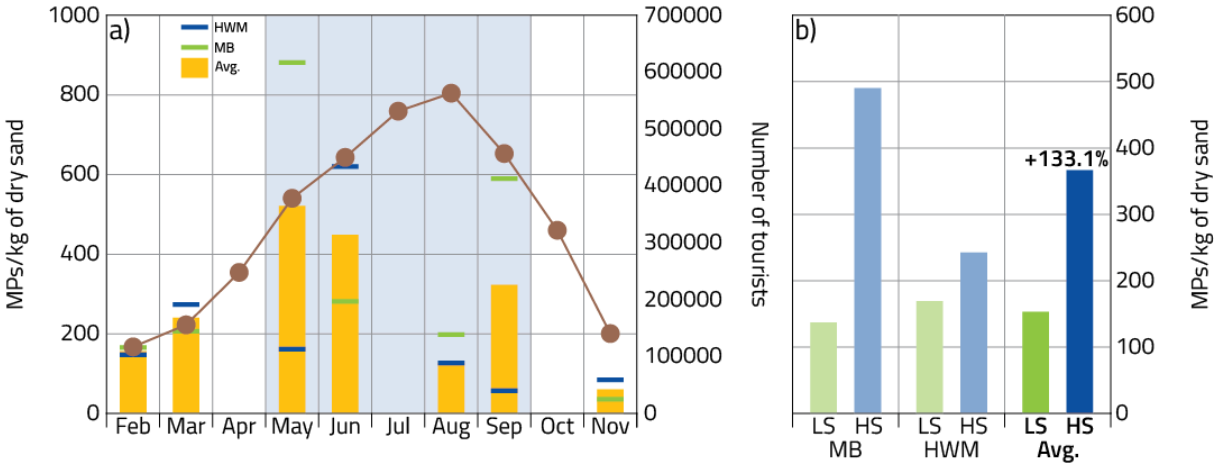

Figure 18: *average concentrations of microplastics for the 8 remote beaches. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[4] for the 8 islands. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

2. Types of microplastics

On average the microplastics extracted from the sand of the 8 selected remote beaches are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=68.6% ±14.8%; LS=71.7% and HS=65.6%), followed by the fragments (Avg=24.2% ±18.1%; LS=20.2% and HS=27.5%), the films (Avg=3.2% ±3.5%; LS=3.4% and HS=3.6%), the foam (Avg=1.4% ±1.9%; LS=0.4% and HS=2.6%), the aggregates (Avg=1.6% ±4.4%; LS=3.3% and HS=0%), the microbeads (Avg=0.5% ±1.3%; LS=1% and HS=0%) and the particles not identified but suspected to be microplastics (Avg=0.4% ±1.2%; LS=0% and HS=0.8%). The proportion of fibers and fragments is higher during the high season compared to the low season (**Fig. 19**).

[4] Data source: monthly average number of tourists welcomed to the 8 islands. See the Part *D Detailed results for each island*.

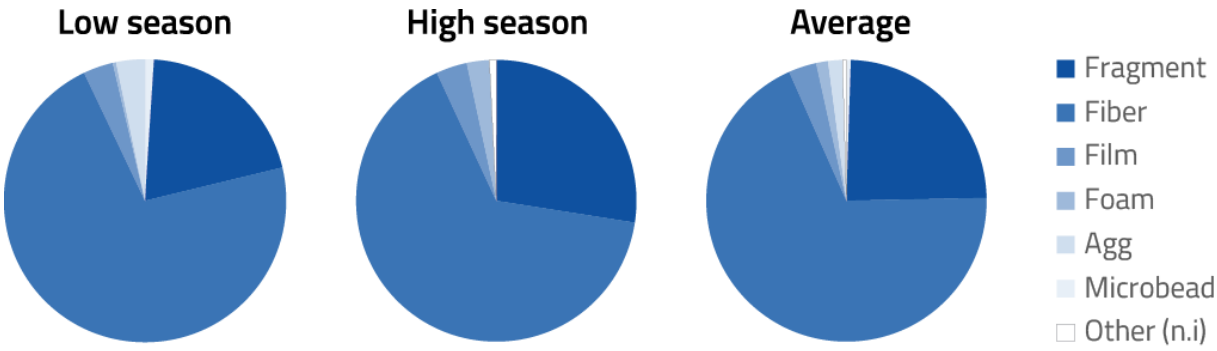

Figure 19: *comparison of the types of microplastics collected in the sand samples of the 8 remote beaches. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

3. Colors of microplastics

On average the microplastics extracted from the sand of the 8 selected remote beaches are dominated by colored particles (Avg=64.5% ±3.1%; LS=61.3% and HS=65.7%), followed by the transparent particles (Avg=16.6% ±10.4%; LS=8.4% and HS=23.1%), the black particles (Avg=15.3% ±13.5%; LS=26.4% and HS=7.3%) and the white particles (Avg=3.7% ±0%; LS=3.9% and HS=3.9%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 20**).

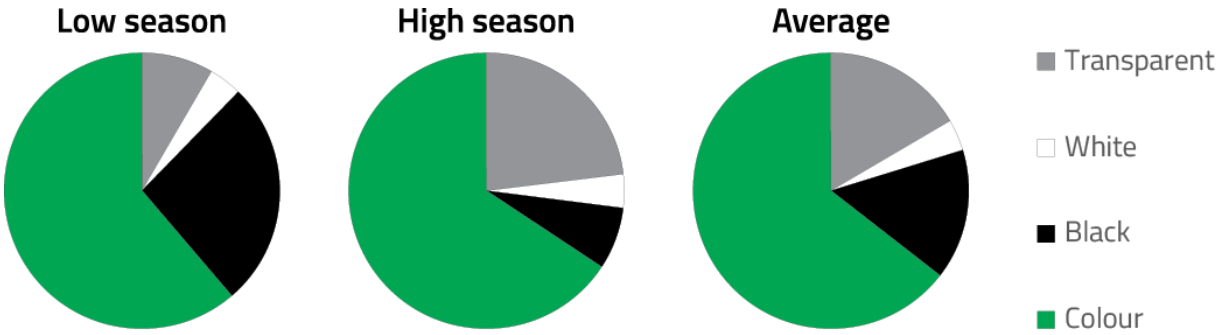

Figure 20: *comparison of the colors of microplastics collected in the sand samples of the 8 remote beaches. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average*

4. Size distribution of microplastics

The size distribution of the microplastics from the 8 selected remote beaches shows a unimodal distribution centered on the 0.2 – 0.5mm class (**Fig. 21**). This class represents 22.7% of all the particles collected. The second most frequent class is the 0.5 – 1.0mm (19.4%) followed by the 1.0 – 2.0mm (18.2%). Taken together these 3 classes represent 60.4% of all the microplastics collected.

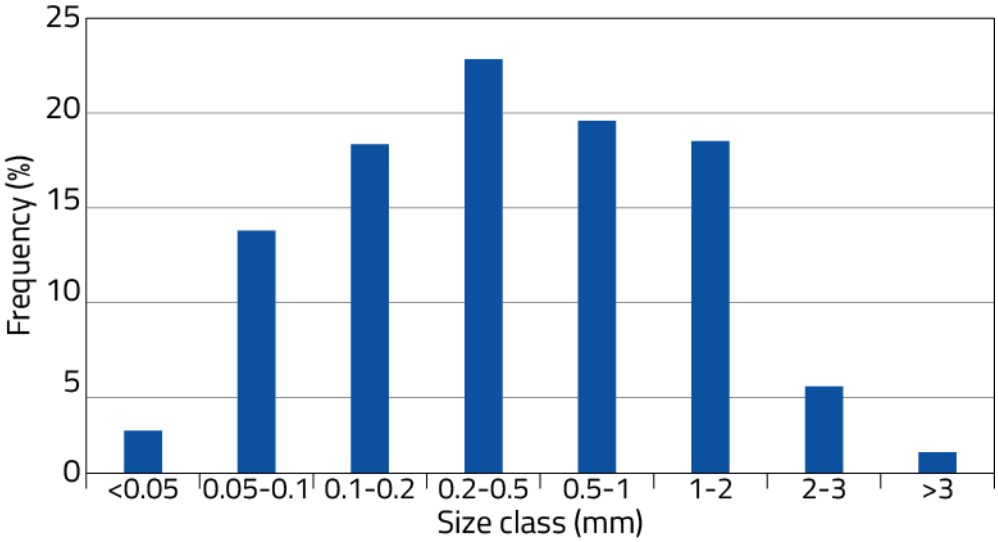

Figure 21: *size distribution of the microplastics collected on the sand samples of the 8 remote beaches.*

V. General conclusions

The 79 campaigns of sand sampling conducted on 3 types of beach of 8 Mediterranean islands in 2017 have revealed that the sand of all the monitored beaches is contaminated with microplastics:

- This is clearly on the touristic beaches that the concentrations of microplastics are the highest (Fig. 22) with an average of 961.9 MPs/kg of dry sand (± 725.9 MPs/kg), followed by the beaches mainly used by locals with an average of 450.1 MPs/kg of dry sand (± 548.1 MPs/kg) and the remote beaches with an average of 275.1 MPs/kg of dry sand (± 240.3 MPs/kg).
- This is during the high season that the concentrations are the highest with 1235.3 MPs/kg of dry sand (± 603.9 MPs) for the touristic sites, 612.8 MPs/kg of dry sand (± 296.3 MPs/kg) for the sites mainly used by locals and 357.1 MPs/kg of dry sand (± 150.3 MPs/kg) for the remote site. During the low season, these concentrations are respectively of 603.9 MPs/kg of dry sand (± 356.5 MPs/kg), 185.7 MPs/kg of dry sand (± 27.0 MPs/kg) and 153.2 MPs/kg of dry sand (± 73.8 MPs/kg).
- This is in the middle of the beach that the concentrations of microplastics are the highest with an average of 1150.4 MPs/kg of dry sand (± 721.8 MPs/kg) for the touristic beaches, 642.9 MPs/kg of dry sand (± 716.8 MPs/kg) for the sites mainly used by locals and 338.9 MPs/kg of dry sand (± 273.9 MPs/kg) for the remote site. At the high water mark, the concentrations of microplastics are respectively of 773.4 MPs/kg of dry sand (± 679.6 MPs/kg), 257.4 MPs/kg of dry sand (± 112.5 MPs/kg) and 211.2 MPs/kg of dry sand (± 179.9 MPs/kg).
- The microplastics found in the sand samples are largely dominated by the fibers, including synthetic and non-synthetic fibers, as they represent on average 65.5% (± 16.3%) of all the particles. The fragments represent the second most important category as they account for 25.9% (± 14.0%) of the particles.
- Coloured particles are the most abundant (66.4 ± 2.6%) followed by the transparent particles (16.2 ± 2.3%), the black particles (12.2 ± 2.1%) and the white particles (5.2 ± 2.1%).
- Finally the particles ranging from 0.2 to 0.5mm are the most frequent as they represent 25.2% of all the particles.

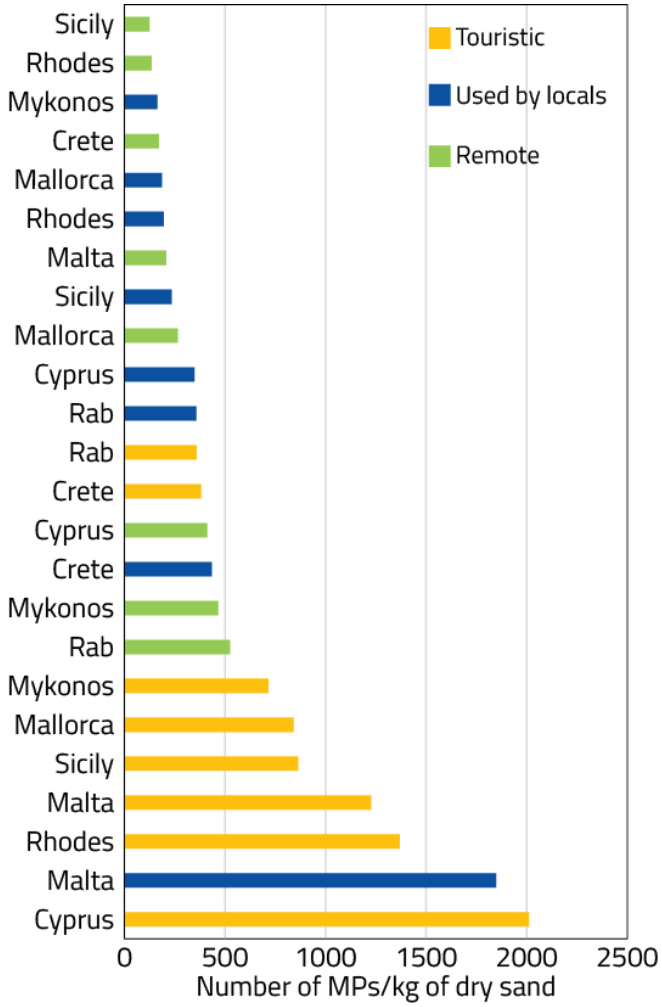

Figure 22: *average concentrations of microplastics for each site.*

Part E: DETAILED RESULTS FOR EACH SELECTED BEACH

I. Mallorca

1. Touristic beach: Torà

a) Characteristics of the beach

The touristic beach of Torá is an urban beach, located in the municipality of Paguera in the SW of Mallorca, facing the sea to the SW. It has a total length of ±500m, a width of ±40m and is composed at 100% of sand with a smooth slope. The monitored fixed portion of the beach has a surface of 2149 m^2. It has a pier situated on its west side. The beach is mainly used for recreational activities during the high season (tourists and locals) and the low season (locals). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach is an urban area with many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 39.5348N, 2.5444E (starting point) and 39.5351N, 2.4555E (ending point) (**Fig. 23**). Drink and food outlets are situated directly on the beach and the closest harbor is situated 4 km away to the SE. The beach is cleaned daily from May to October.

Figure 23: *location map of the sampling sites of the beach of Torá. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The touristic beach of Torá was sampled for microplastics in February, June, September and November of 2017 (**Fig. 24**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in February (194.7 MPs/kg of dry sand ± 25.4 MPs/kg), while the highest averaged concentration is observed in June (2113.3 MPs/kg of dry sand ± 275.4 MPs/kg) (**Fig. 24a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in November (284.9 MPs/kg of dry sand ± 37.1 MPs/kg) and the highest in June (1832.6 MPs/kg of dry sand ± 238.8 MPs/kg) (**Fig. 24a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in February (276.6 MPs/kg of dry sand ± 81.8

MPs/kg) and the highest in June (1972.9 MPs/kg of dry sand ± 140.3 MPs/kg) (**Fig. 24a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Mallorca, despite the slight increase in November: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 24a**). During the low season the average concentrations is of 637.4 MPs/kg of dry sand (± 442.7 MPs/kg) for the middle of the beach, of 321.6 MPs/kg of dry sand (± 36.7 MPs/kg) for the high water mark and of 479.5 MPs/kg of dry sand (± 203 MPs/kg) for the average (**Fig. 24b**). During the high season the average concentrations is of 1274.5 MPs/kg of dry sand (± 838.8 MPs/kg) for the middle of the beach, of 1126.3 MPs/kg of dry sand (± 706.3 MPs/kg) for the high water mark and of 1200.4 MPs/kg of dry sand (± 772.5 MPs/kg) for the average (**Fig. 24b**). The concentrations are always higher during the high season, no matter the origin of the sample. Finally an average increase of +150.3% of the concentrations of microplastics is observed from the low to the high season (**Fig. 24b**).

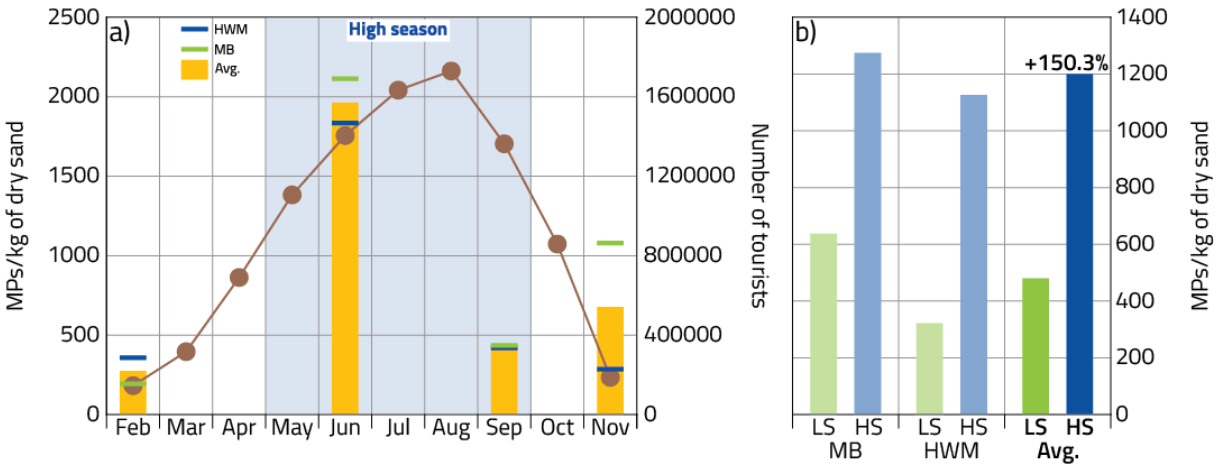

Figure 24: *average concentrations of microplastics for the beach of Torà. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[5] in Mallorca. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Torà are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=81.4% ±20.2%; LS=80.3% and HS=82.4%), followed by the fragments (Avg=16.9% ±18.6%; LS=19% and HS=14.7%), the films (Avg=1.4% ±2.6%; LS=0.6% and HS=2.2%), the foam (Avg=0.2% ±0.5%; LS=0% and HS=0.4%) and the aggregates (Avg=0.2% ±0.5%; LS=0% and HS=0.3%). No microbeads were found. The proportion of fibers and fragments is higher during the high season compared to the low season (**Fig. 25**).

[5] Data source: number of tourists welcomed on Mallorca in 2014, https://ibestat.caib.es

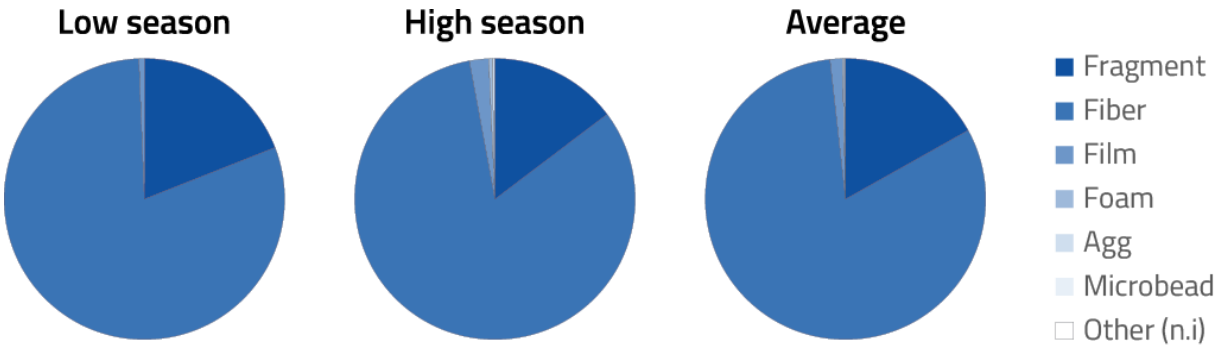

Figure 25: *comparison of the types of microplastics collected in the sand samples of the beach of Torà. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Torà are dominated by colored particles (Avg=58.6% ±8.9%; LS=52.3% and HS=64.9%), followed by the transparent particles (Avg=29.1% ±4.1%; LS=31.9% and HS=26.2%), the black particles (Avg=11.8% ±4.7%; LS=15.1% and HS=8.5%) and the white particles (Avg=0.5% ±0.2%; LS=0.6% and HS=0.4%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 26**).

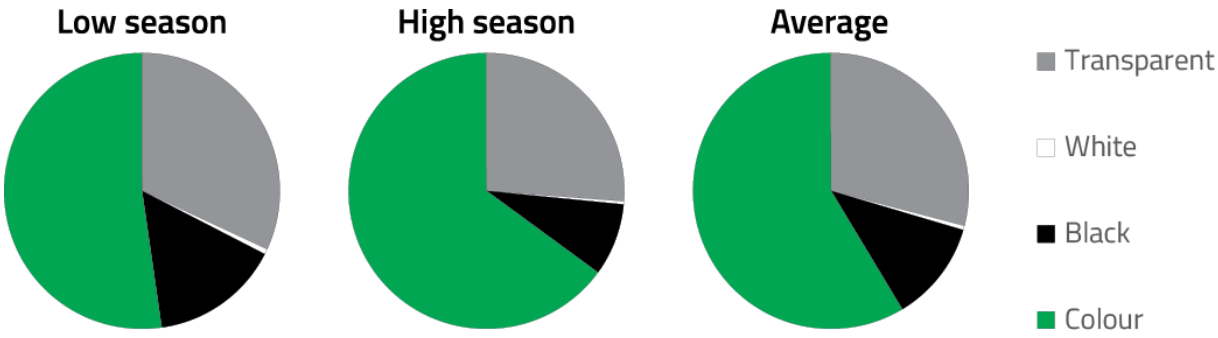

Figure 26: *comparison of the colors of microplastics collected in the sand samples of the beach of Torà. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

2. Beach mainly used by locals: Es Caragol

a) Characteristics of the beach

The beach of Es Caragol was selected as it is a popular beach mainly used by locals. It is a rural beach located in the municipality of Santanyi in the SE of Mallorca. The beach is facing the sea to the SW, has a total length of ±500m, a width of ±60m and is composed at 100% of sand with a smooth slope. The monitored fixed portion of the beach has a surface of 6015 m^2. The beach is mainly used for recreational activities during both the high and low seasons by locals. It is only accessible by boats and for pedestrians. In the area situated directly behind the beach, no services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 39.2765N, 3.0439E (starting point) and 39.2773N, 3.0440E (ending point) (**Fig. 27**). The closest harbor is situated 7.8 km away to the NW. The beach is cleaned 2 times a week from May to October.

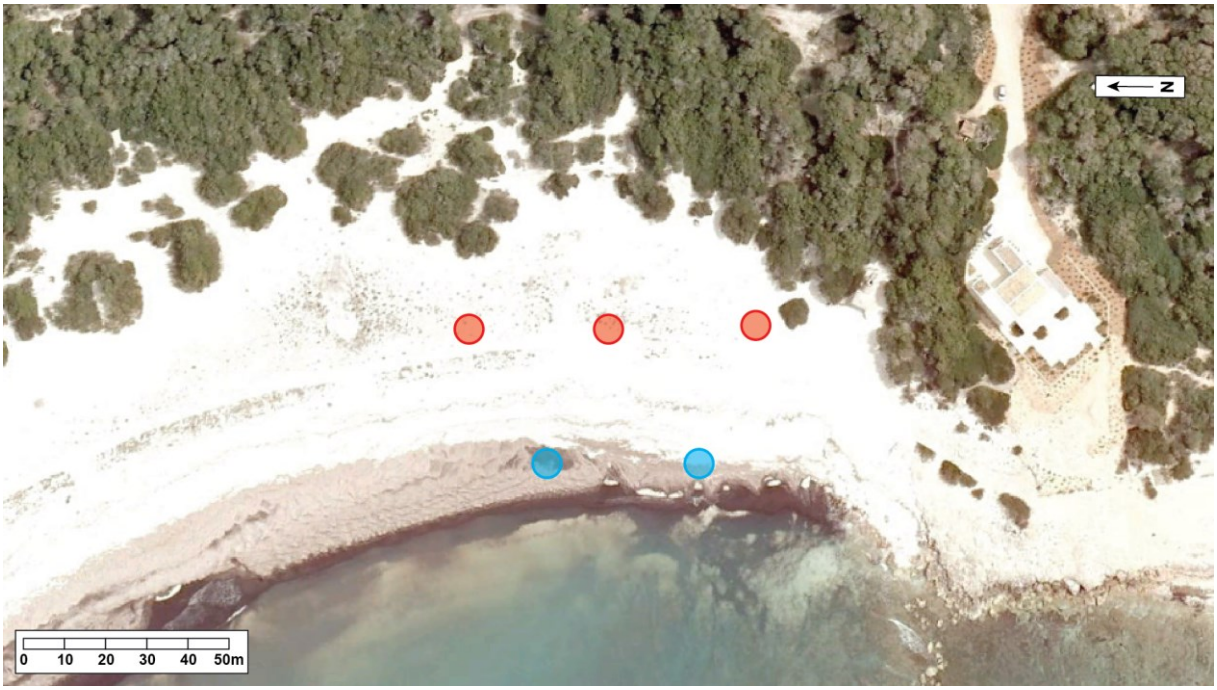

Figure 27: *location map of the sampling sites of the beach of Es Caragol. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The beach of Es Caragol, mainly used by locals, was sampled for microplastics in February, June, September and November of 2017 (**Fig. 28**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in February (150.8 MPs/kg of dry sand ± 19.6 MPs/kg), while the highest averaged concentration is observed in September (476.7 MPs/kg of dry sand ± 62.1 MPs/kg) (**Fig. 28a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in November (25.9 MPs/kg of dry sand ± 3.4 MPs/kg) and the highest in September (252.7 MPs/kg of dry sand ± 32.9 MPs/kg) (**Fig. 28a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in February (106 MPs/kg of dry sand ± 44.7 MPs/kg) and the highest in September (364.7 MPs/kg of dry sand ± 112 MPs/kg) (**Fig. 28a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Mallorca: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (Fig. 29a). During the low season the average concentrations is of 188 MPs/kg of dry sand (± 37.2 MPs/kg) for the middle of the beach, of 43.6 MPs/kg of dry sand (± 17.7 MPs/kg) for the high water mark and of 115.8 MPs/kg of dry sand (± 9.8 MPs/kg) for the average (**Fig. 28b**). During the high season the average concentrations is of 325.8 MPs/kg of dry sand (± 150.9 MPs/kg) for the middle of the beach, of 182.5 MPs/kg of dry sand (± 70.2 MPs/kg) for the high water mark and of 254.1 MPs/kg of dry sand (± 110.6 MPs/kg) for the average (**Fig. 28b**). The concentrations are always higher during the high season, no matter the origin of the sample. Finally an average increase of +119.5% of the concentrations of microplastics is observed from the low to the high season (**Fig. 28b**).

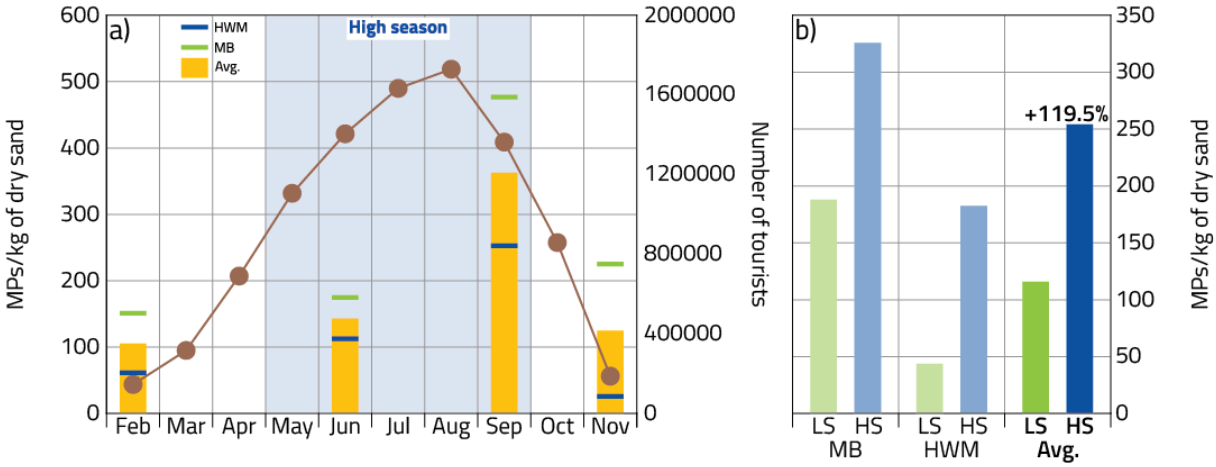

Figure 28: *average concentrations of microplastics for the beach of Es Caragol. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[6] in Mallorca. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Es Caragol are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=62.5% ±38.7%; LS=71.9% and HS=53.1%), followed by the fragments (Avg=20% ±26.7%; LS=3.1% and HS=36.8%), the foam (Avg=14.3% ±35%; LS=25% and HS=3.6%) and the films (Avg=3.2% ±7.1%; LS=0% and HS=6.5%). No aggregates and microbeads were found. The proportion of fragments is higher during the high season compared to the low season (**Fig. 29**).

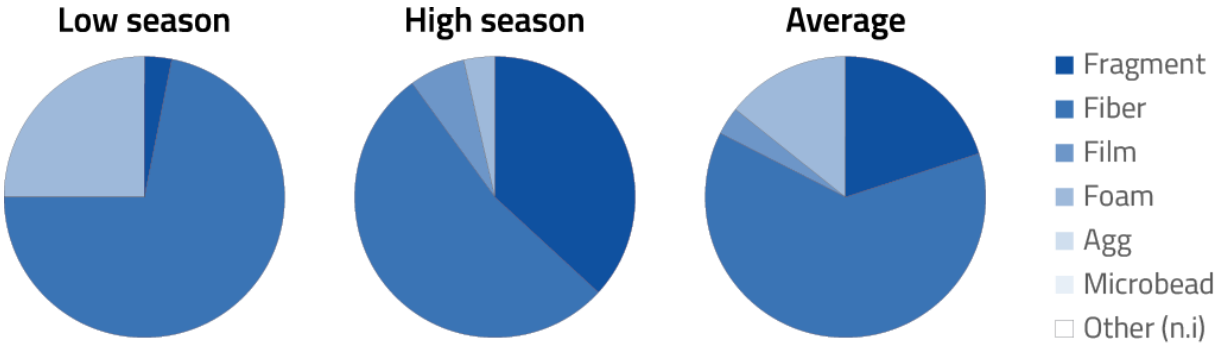

Figure 29 *comparison of the types of microplastics collected in the sand samples of the beach of Es Caragol. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Es Caragol are dominated by colored particles (Avg=66.2% ±30%; LS=45% and HS=87.4%), followed by the black particles (Avg=17% ±11.3%; LS=25% and HS=9%), the white particles (Avg=14.3% ±15.2%; LS=25% and HS=3.6%) and the transparent particles (Avg=2.5% ±3.5%; LS=5% and HS=0%). The proportion of colored particles is higher during the high season compared to the low season (Fig. **30**).

[6] Data source: number of tourists welcomed on Mallorca in 2014, https://ibestat.caib.es

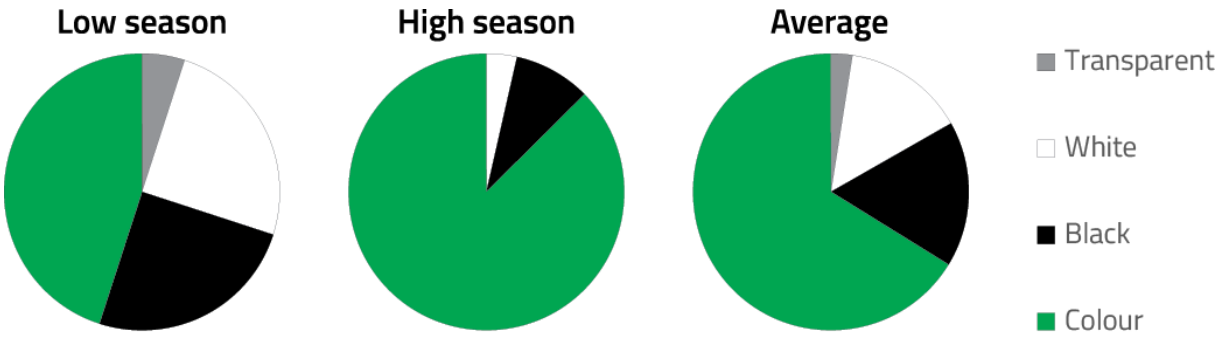

Figure 30: *comparison of the colors of microplastics collected in the sand samples of the beach of Es Caragol. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

3. Remote beach: Sa Canova

a) Characteristics of the beach

The beach of Sa Canova is a natural beach, located in the municipality of Colòna de Sant Pere in the NE of Mallorca, facing the sea to the north. It has a total length of ±1500m, a width of ±40m and is composed at 100% of sand with a smooth slope. The monitored fixed portion of the beach has a surface of 4918 m^2. The beach is mainly used for recreational activities: swimming and sunbathing during the high season and walks during the low season. It is only accessible by boats and for pedestrians. In the area situated directly behind the beach, no services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 39.7294N, 3.2506E (starting point) and 39.7292N, 3.2516E (ending point) (**Fig. 31**). The closest harbor is situated 16 km away to the NW. The beach is cleaned once every 2 weeks from May to October.

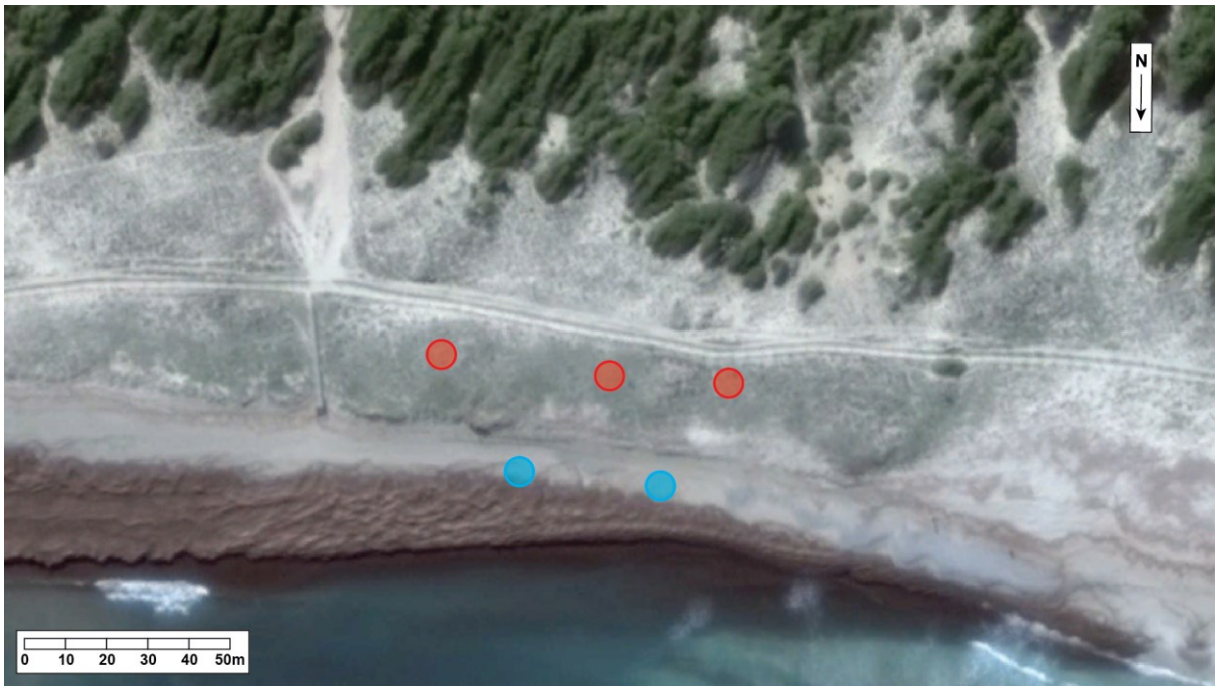

Figure 31: *location map of the sampling sites of the beach of Sa Canova. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The remote beach of Sa Canova was sampled for microplastics in February, June, September and November of 2017 (**Fig. 32**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in November (56.2 MPs/kg of dry sand ±

7.3 MPs/kg), while the highest averaged concentration is observed in September (1495 MPs/kg of dry sand ± 194.8 MPs/kg) (**Fig. 32a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in November (0 MPs/kg of dry sand ± 0 MPs/kg) and the highest in February (245.1 MPs/kg of dry sand ± 31.9 MPs/kg) (**Fig. 32a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in November (28.1 MPs/kg of dry sand ± 28.1 MPs/kg) and the highest in September (762 MPs/kg of dry sand ± 732.9 MPs/kg) (**Fig. 32a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Mallorca: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 32a**). During the low season the average concentrations is of 93.2 MPs/kg of dry sand (± 36.9 MPs/kg) for the middle of the beach, of 122.6 MPs/kg of dry sand (± 122.6 MPs/kg) for the high water mark and of 107.9 MPs/kg of dry sand (± 79.7 MPs/kg) for the average (**Fig. 32b**). During the high season the average concentrations is of 788.5 MPs/kg of dry sand (± 706.5 MPs/kg) for the middle of the beach, of 55.2 MPs/kg of dry sand (± 26.1 MPs/kg) for the high water mark and of 421.9 MPs/kg of dry sand (± 340.2 MPs/kg) for the average (**Fig. 32b**). The concentrations are higher during the high season for the samples from the middle of the beach and lower for the samples from the high water mark. Finally an average increase of +291.1% of the concentrations of microplastics is observed from the low to the high season (**Fig. 32b**).

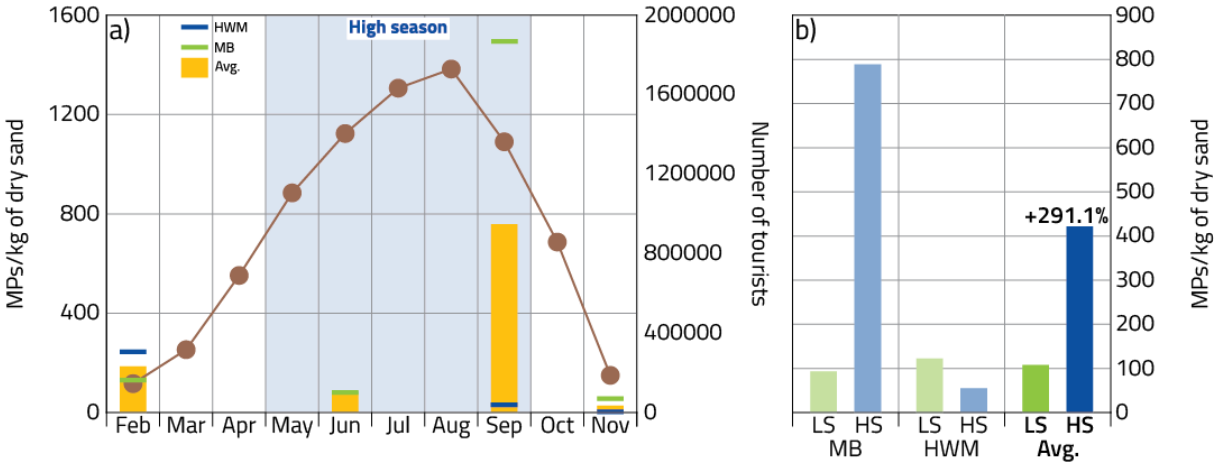

Figure 32: *average concentrations of microplastics for the 24 selected beaches. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[7] in Mallorca. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Sa Canova are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=80.6% ±19.7%; LS=76.7% and HS=84.6%), followed by the films (Avg=9.7% ±18.7%; LS=16.7% and HS=2.8%) and the fragments (Avg=9.6% ±13.5%; LS=6.7% and HS=12.6%). No aggregates, foam, films and microbeads were found. The proportion of fragments is higher during the high season compared to the low season (**Fig. 33**).

[7] Data source: number of tourists welcomed on Mallorca in 2014, https://ibestat.caib.es

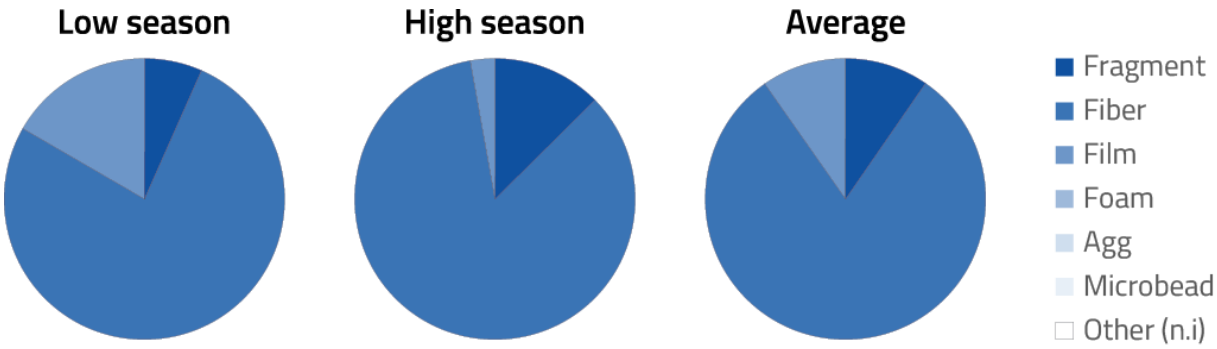

Figure 33: *comparison of the types of microplastics collected in the sand samples of the beach of Sa Canova. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Sa Canova are dominated by colored particles (Avg=56.1% ±1.8%; LS=54.8% and HS=57.4%), followed by the transparent particles (Avg=25.2% ±11.5%; LS=17% and HS=33.3%) and the black particles (Avg=18.7% ±13.3%; LS=28.1% and HS=9.3%). No white particles were found. The proportion of colored particles is higher during the high season compared to the low season (**Fig. 34**).

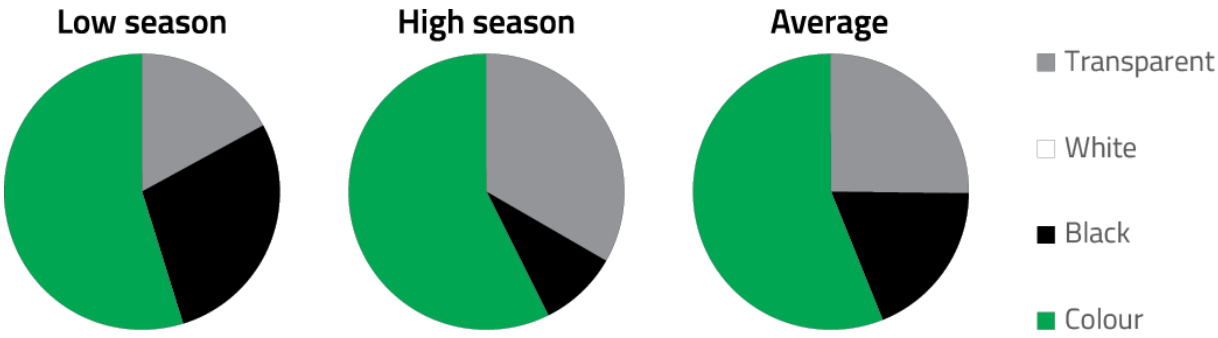

Figure 34: *comparison of the colors of microplastics collected in the sand samples of Sa Canova. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

4. Summary

The 12 campaigns of sand sampling conducted on 3 beaches of Mallorca in 2017 have revealed that the sand of all the monitored beaches is contaminated with microplastics:

- This is on the touristic beach that the concentrations of microplastics are the highest with an average of 840 MPs/kg of dry sand (± 703.6 MPs/kg), followed by the remote beach with an average of 264.9 MPs/kg of dry sand (± 470.1 MPs/kg) and the beach mainly used by locals with an average of 185 MPs/kg of dry sand (± 131.6 MPs/kg).
- This is during the high season that the concentrations are the highest with 1200.4 MPs/kg of dry sand (± 778.9 MPs) for the touristic beach of Torá, 421.9 MPs/kg of dry sand (± 619.9 MPs/kg) for the remote beach of Sa Canova and 254.1 MPs/kg of dry sand (± 137.8 MPs/kg) for the beach of Es Caragol. During the low season, these concentrations are respectively of 479.5 MPs/kg of dry sand (± 351.5 MPs/kg), 107.9 MPs/kg of dry sand (± 91.7 MPs/kg) and 115.8 MPs/kg of dry sand (± 77.9 MPs/kg)
- This is in the middle of the beach that the concentrations of microplastics are the highest with an average of 956 MPs/kg of dry sand (± 742.4 MPs/kg) for the touristic beach, 440.8 MPs/kg of dry sand (± 609.2 MPs/kg) for the remote beach and 256.9 MPs/kg of dry sand (± 129.7

MPs/kg) for the beach mainly used by locals. At the high water mark, the concentrations of microplastics are respectively of 724 MPs/kg of dry sand (± 641.8 MPs/kg), 88.9 MPs/kg of dry sand (± 94.8 MPs/kg) and 113 MPs/kg of dry sand (± 86.3 MPs/kg)

- The microplastics found in the sand samples are largely dominated by the fibers, including synthetic and non-synthetic fibers, as they represent on average 73.4% (± 24.3%) of all the particles. The fragments represent the second most important category as they account for 21.4% (± 21.2%) of the particles.
- Finally, colored particles are the most abundant (60.3 ± 4.3%) followed by the transparent particles (18.9 ± 11.7%), the black particles (15.8 ± 2.9%) and the white particles (4.9 ± 6.6%).

II. Sicily

1. Touristic beach: Giardini Naxos

a) Characteristics of the beach

The touristic beach of Giardini Naxos is an urban beach, located in the municipality of Giardini Naxos in the eastern side of Sicily, facing the sea to the NE. It has a total length of 528m, a width ranging from 40m to 100m and is composed at 95% of sand and 5% of pebbles with a very smooth slope. The monitored fixed portion of the beach has a surface of 6507 m^2. It has a pier situated on its SE side. The beach is mainly used for recreational activities during the high season (swimming, sunbathing, fishing and sailing) and the low season (fishing). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach is an urban area with many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 37.8261N, 15.2700E (starting point) and 37.8254N, 15.2704E (ending point) (**Fig. 35**). Drink and food outlets are situated directly on the beach and the closest harbor is situated 0.1km away to the SE. The beach is cleaned weekly from August to September.

Figure 35: *location map of the sampling sites of the beach of Giardini Naxos. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The touristic beach of Giardini Naxos was sampled for microplastics in March, June, September and November of 2017 (**Fig. 36**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in March (323.8 MPs/kg of dry sand ± 42.2 MPs/kg), while the highest averaged concentration is observed in September (1956.1 MPs/kg of dry sand ± 254.9 MPs/kg) (**Fig. 36a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in November (113.7 MPs/kg of dry sand ± 14.8 MPs/kg) and the highest in September (685.5 MPs/kg of dry sand ± 89.3 MPs/kg) (**Fig. 36a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in March (390.2 MPs/kg of dry sand ± 66.4 MPs/kg) and the highest in September (1320.8 MPs/kg of dry sand ± 635.3 MPs/kg) (**Fig. 36a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Sicily: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 36a**). During the low season the average concentrations is of 788.1 MPs/kg of dry sand (± 464.3 MPs/kg) for the middle of the beach, of 285.1 MPs/kg of dry sand (± 171.4 MPs/kg) for the high water mark and of 536.6 MPs/kg of dry sand (± 146.4 MPs/kg) for the average (**Fig. 36b**). During the high season the average concentrations is of 1954.8 MPs/kg of dry sand (± 1.4 MPs/kg) for the middle of the beach, of 425 MPs/kg of dry sand (± 260.5 MPs/kg) for the high water mark and of 1189.9 MPs/kg of dry sand (± 130.9 MPs/kg) for the average (**Fig. 36b**). The concentrations are always higher during the high season, no matter the origin of the sample. Finally an average increase of +121.7% of the concentrations of microplastics is observed from the low to the high season (**Fig. 36b**).

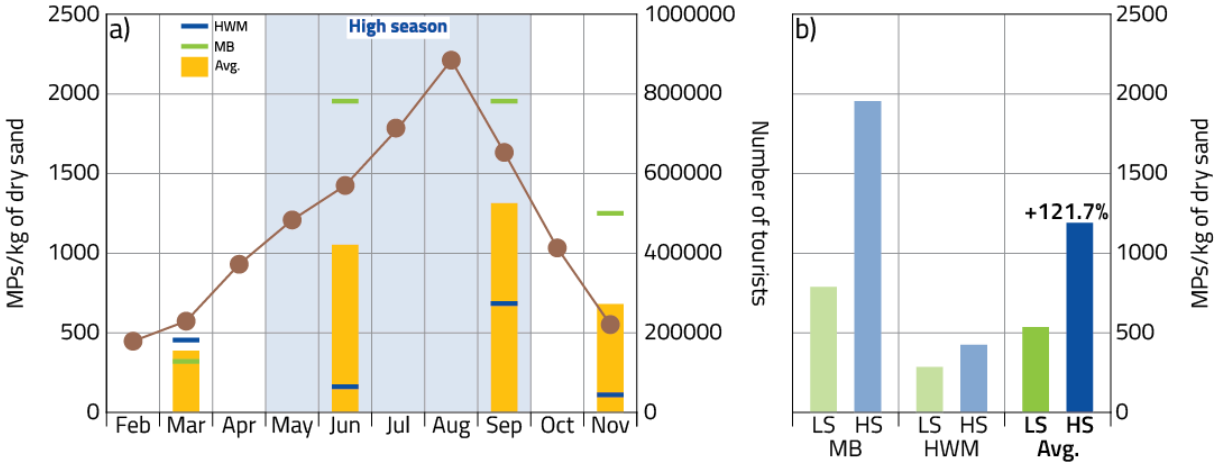

Figure 36: *average concentrations of microplastics for the beach of Giardini Naxos. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[8] in Sicily. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

[8] Data source: data extrapolated for 2015, from the monthly distribution of overnight stays in travel accomodation in the italian region of Sicily and the anual number of tourists welcomed on Sicily, https://www.istat.it/

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Giardini Naxos are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=57.4% ±31.9%; LS=64.2% and HS=50.7%), followed by the fragments (Avg=29.8% ±17.1%; LS=21.4% and HS=38.3%), the films (Avg=7% ±17.4%; LS=13% and HS=1%), the foam (Avg=4.7% ±12.7%; LS=0% and HS=9.3%), the aggregates (Avg=0.9% ±2%; LS=1.4% and HS=0.3%) and the microbeads (Avg=0.2% ±0.5%; LS=0% and HS=0.3%). The proportion of fragments is higher during the high season compared to the low season (**Fig. 37**).

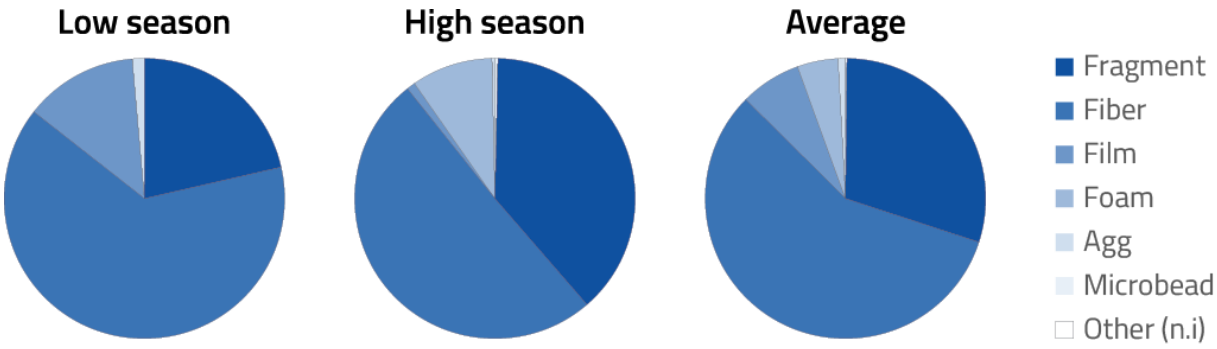

Figure 37: *comparison of the types of microplastics collected in the sand samples of the beach of Giardini Naxos. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Giardini Naxos are dominated by colored particles (Avg=71.5% ±2.4%; LS=73.3% and HS=69.8%), followed by the black particles (Avg=12.1% ±9.8%; LS=19.1% and HS=5.2%), the transparent particles (Avg=11.3% ±5.2%; LS=7.6% and HS=14.9%) and the white particles (Avg=5% ±7.1%; LS=0% and HS=10.1%). The proportion of colored particles is lower during the high season compared to the low season (**Fig. 38**).

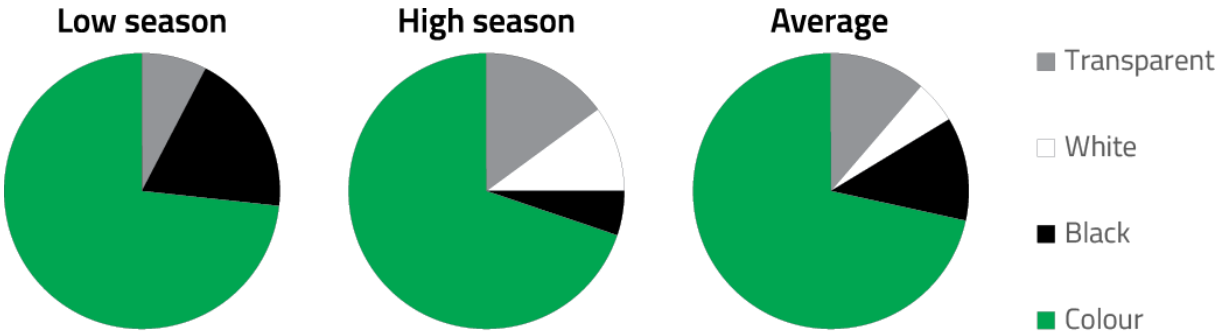

Figure 38: *comparison of the colors of microplastics collected in the sand samples of the beach of Giardini Naxos. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

2. Beach mainly used by locals: Letojani

a) Characteristics of the beach

The beach of Letojani was selected as it is a popular beach mainly used by locals. It is a semi-urban beach, located in the municipality of Letojani in the eastern side of Sicily, facing the sea to the SE. It has a total length of 2193m, a width ranging from 25 to 65m and is composed at 90% of pebbles and 10% of sand with a slope of 10%. The monitored fixed portion of the beach has a surface of 3680 m^2. The beach is mainly used for recreational activities during the high season (swimming, sunbathing,

fishing and local people) and the low season (fishing). It is accessible by vehicles/boats and for pedestrians. In the area situated directly behind the beach, very limited services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 37.8851N, 15.3136E (starting point) and 37.8844N, 15.3130E (ending point) (**Fig. 39**). Drink and food outlets are situated directly on the beach and the closest harbor is situated 7.7 km away to the SW. The beach is cleaned twice a week from July to September.

Figure 39: *location map of the sampling sites of the beach of Giardini Naxos. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The beach of Letojani, mainly used by locals, was sampled for microplastics in March, June, September and November of 2017 (**Fig. 40**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in March (27.7 MPs/kg of dry sand ± 3.6 MPs/kg), while the highest averaged concentration is observed in June (357.5 MPs/kg of dry sand ± 46.6 MPs/kg) (**Fig. 40a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in November (163.9 MPs/kg of dry sand ± 21.4 MPs/kg) and the highest in March (411.3 MPs/kg of dry sand ± 53.6 MPs/kg) (**Fig. 40a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in November (108.5 MPs/kg of dry sand ± 55.4 MPs/kg) and the highest in June (349.3 MPs/kg of dry sand ± 8.1 MPs/kg) (**Fig. 40a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Sicily: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 40a**). During the low season the average concentrations is of 40.4 MPs/kg of dry sand (± 12.7 MPs/kg) for the middle of the beach, of 287.6 MPs/kg of dry sand (± 123.7 MPs/kg) for the high water mark and of 164 MPs/kg of dry sand (± 55.5 MPs/kg) for the average (**Fig. 40b**). During the high season the average concentrations is of 356.1 MPs/kg of dry sand (± 1.3 MPs/kg) for the middle of the beach, of 253 MPs/kg of dry sand (± 88.2 MPs/kg) for the high water mark and of 304.6 MPs/kg of dry sand (± 44.8 MPs/kg) for the average (**Fig.**

40b). The concentrations are higher during the high season for the samples from the middle of the beach and lower for the samples from the high water mark. Finally an average increase of +85.7% of the concentrations of microplastics is observed from the low to the high season (**Fig. 40b**).

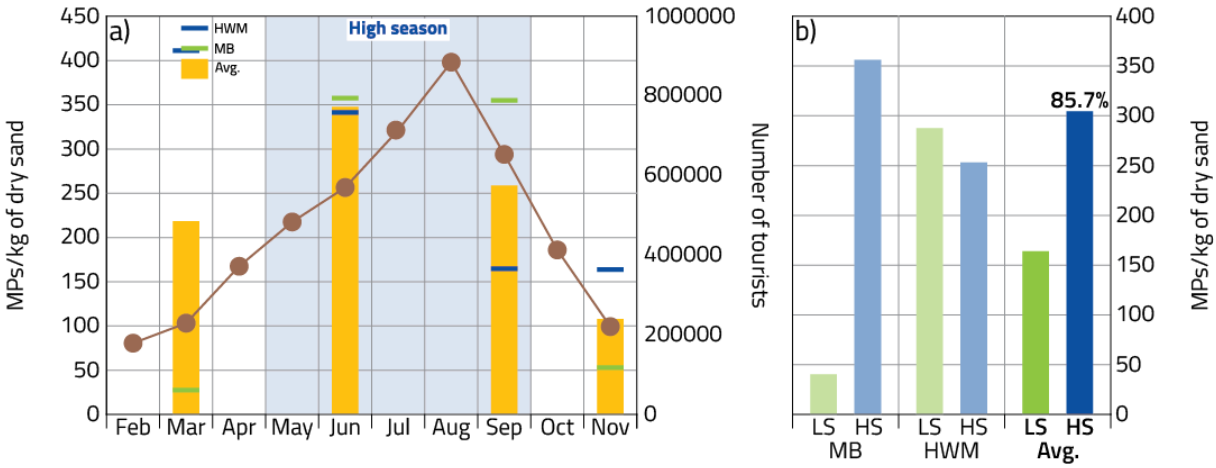

Figure 40: *average concentrations of microplastics for the beach of Letojani. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[9] in Sicily. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Letojani are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=87% ±11.5%; LS=90.8% and HS=83.2%), followed by the fragments (Avg=8.5% ±8.7%; LS=5.8% and HS=11.3%), the films (Avg=2.7% ±5.4%; LS=0% and HS=5.5%), the foam (Avg=0.8% ±2.4%; LS=1.7% and HS=0%) and the aggregates (Avg=0.8% ±2.4%; LS=1.7% and HS=0%). No microbeads were found. The proportion of the fragments is higher during the high season compared to the low season (**Fig. 41**).

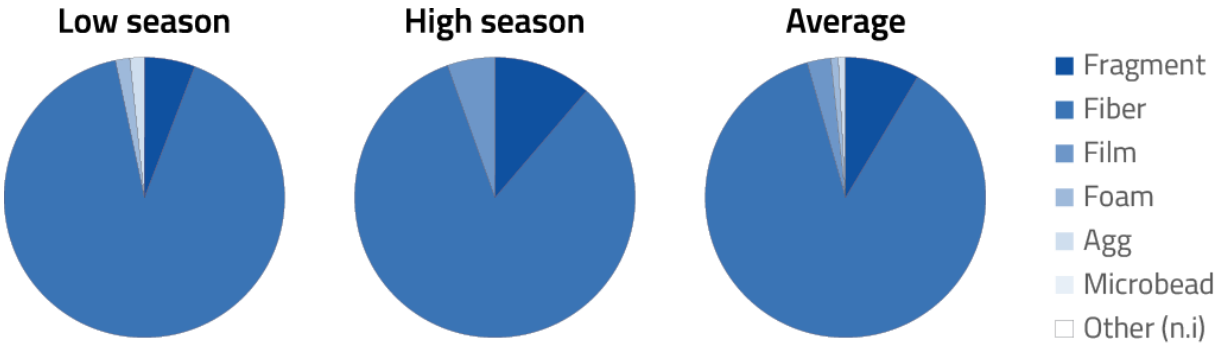

Figure 41: *comparison of the types of microplastics collected in the sand samples of the beach of Letojani. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

[9] Data source: data extrapolated for 2015, from the monthly distribution of overnight stays in travel accomodation in the italian region of Sicily and the anual number of tourists welcomed on Sicily, https://www.istat.it/

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Letojani are dominated by colored particles (Avg=65% ±18.9%; LS=51.7% and HS=78.3%), followed by the transparent particles (Avg=31.4% ±19.2%; LS=45% and HS=17.8%), the black particles (Avg=1.8% ±0.2%; LS=1.7% and HS=1.9%) and the white particles (Avg=1.8% ±0.2%; LS=1.7% and HS=1.9%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 42**).

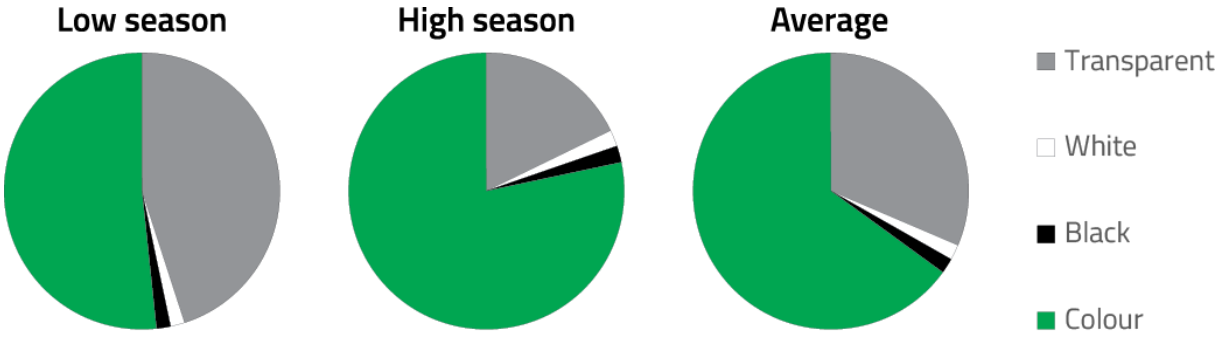

Figure 42: *comparison of the colors of microplastics collected in the sand samples of the beach of Letojani. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

3. Remote beach: Fondaco Parrino

a) Characteristics of the beach

The beach of Fondaco Parrino is a semi-rural beach, located in the municipality of Letojani in the eastern side of Sicily, facing the sea to the SE. It has a total length of 612m, a width ranging from 12m to 47m and is composed at 90% of pebbles and 10% of sand with a slope of 5%. The monitored fixed portion of the beach has a surface of 2301 m^2. The beach is mainly used for recreational activities during the high season (local people, swimming and sunbathing). It is only accessible for pedestrians. In the area situated directly behind the beach, no services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 37.9068N, 15.3373E (starting point) and 37.9071N, 15.3377E (ending point) (**Fig. 43**). Drink and food outlets are situated directly on the beach and the closest harbor is situated 19 km away to the SW. The beach is cleaned only once in August by local private owners.

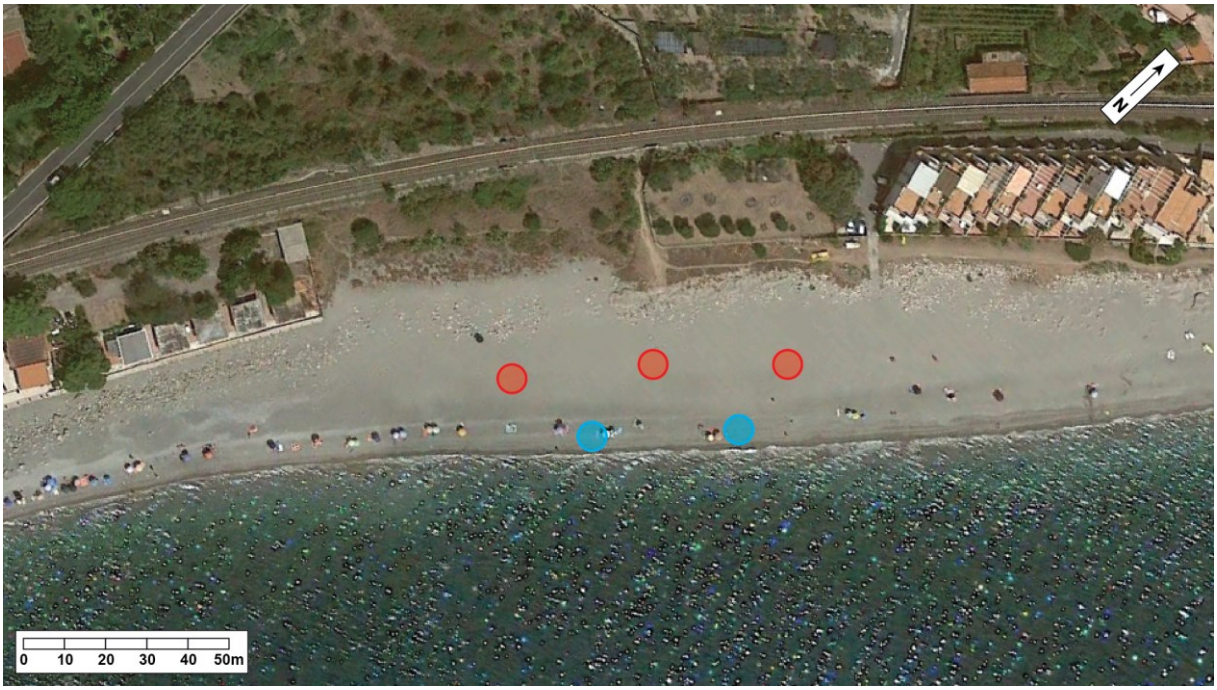

Figure 43: *location map of the sampling sites of the beach of Fondaco Parrino. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The remote beach of Fondaco Parrino was sampled for microplastics in March, June, September and November of 2017 (**Fig. 44**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in November (28.4 MPs/kg of dry sand ± 3.7 MPs/kg), while the highest averaged concentration is observed in June (284.3 MPs/kg of dry sand ± 37 MPs/kg) (**Fig. 44a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in November (85.3 MPs/kg of dry sand ± 11.1 MPs/kg) and the highest in March (199 MPs/kg of dry sand ± 25.9 MPs/kg) (**Fig. 44a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in November (56.9 MPs/kg of dry sand ± 28.4 MPs/kg) and the highest in June (199 MPs/kg of dry sand ± 85.3 MPs/kg) (**Fig. 44a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Sicily: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 44a**). During the low season the average concentrations is of 56.9 MPs/kg of dry sand (± 28.4 MPs/kg) for the middle of the beach, of 142.2 MPs/kg of dry sand (± 56.9 MPs/kg) for the high water mark and of 99.5 MPs/kg of dry sand (± 42.6 MPs/kg) for the average (**Fig. 44b**). During the high season the average concentrations is of 199 MPs/kg of dry sand (± 85.3 MPs/kg) for the middle of the beach, of 99.5 MPs/kg of dry sand (± 14.2 MPs/kg) for the high water mark and of 149.3 MPs/kg of dry sand (± 49.8 MPs/kg) for the average (**Fig. 44b**). The concentrations are higher during the high season for the samples from the middle of the beach and lower for the samples from the high water mark. Finally an average increase of +50% of the concentrations of microplastics is observed from the low to the high season (**Fig. 44b**).

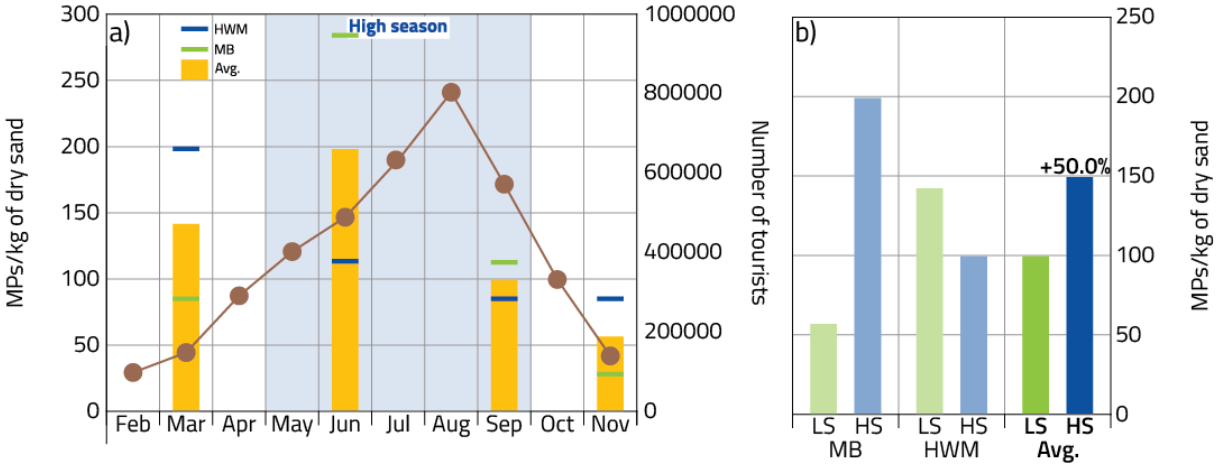

Figure 44: *average concentrations of microplastics for the beach of Fondaco Parrino. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[10] in Sicily. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Composition of the microplastics

On average the microplastics extracted from the sand of the beach of Fondaco Parino are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=79.6% ±34.2%; LS=92.9% and HS=66.3%), followed by the fragments (Avg=8.3% ±23.6%; LS=0% and HS=16.7%), the films (Avg=5.4% ±11.8%; LS=0% and HS=10.8%), the foam (Avg=3.1% ±8.8%; LS=0% and HS=6.3%) and the microbeads (Avg=3.6% ±10.1%; LS=7.1% and HS=0%). No aggregates were found. The proportion of the fragments is higher during the high season compared to the low season (**Fig. 45**).

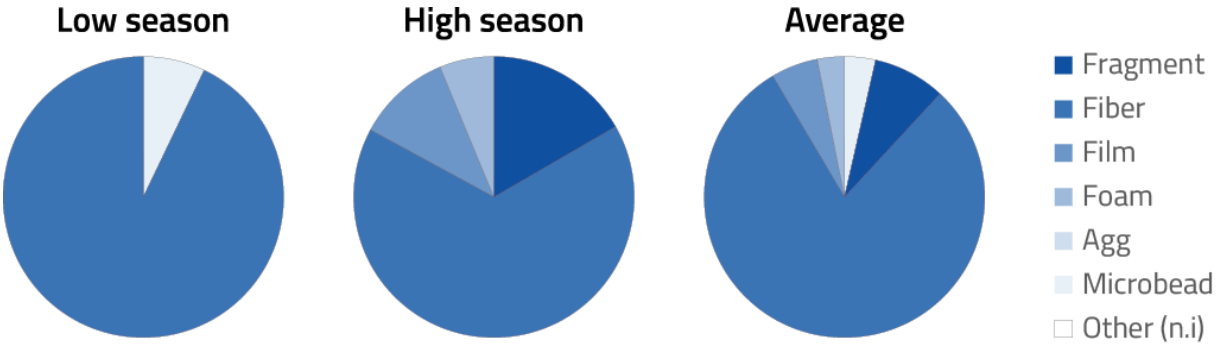

Figure 45: *comparison of the types of microplastics collected in the sand samples of the beach of Fondaco Parrino. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of the microplastics

On average the microplastics extracted from the sand of the beach of Fondaco Parrino are dominated by colored particles (Avg=51.3% ±6.6%; LS=56% and HS=46.7%), followed by the transparent particles (Avg=29.2% ±5.9%; LS=25% and HS=33.3%), the black particles (Avg=16.4% ±3.7%; LS=19% and

[10] Data source: data extrapolated for 2015, from the monthly distribution of overnight stays in travel accomodation in the italian region of Sicily and the anual number of tourists welcomed on Sicily, https://www.istat.it/

HS=13.8%) and the white particles (Avg=3.1% ±4.4%; LS=0% and HS=6.3%). The proportion of colored particles is lower during the high season compared to the low season (**Fig. 46**).

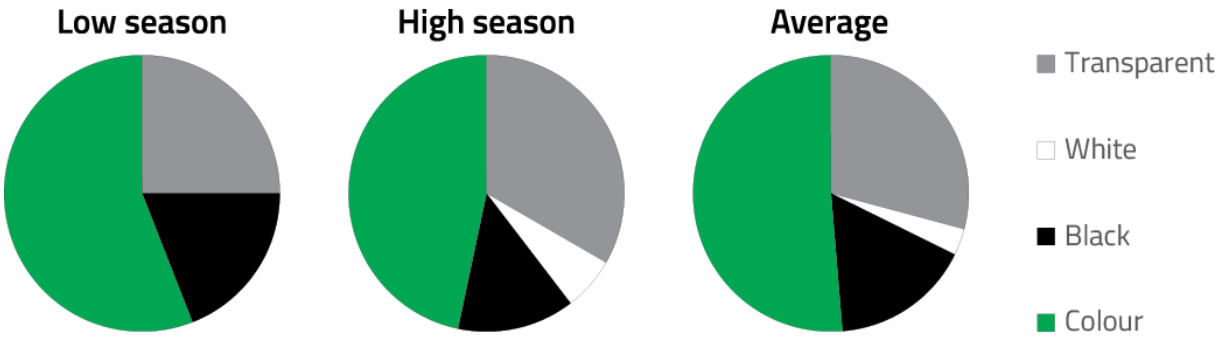

Figure 46: *comparison of the colors of microplastics collected in the sand samples of the becah of Fondaco Parrino. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

4. Summary

The 12 campaigns of sand sampling conducted on 3 beaches of Sicily in 2017 have revealed that the sand of all the monitored beaches is contaminated with microplastics:

- This is on the touristic beach that the concentrations of microplastics are the highest with an average of 863.3 MPs/kg of dry sand (± 713.5 MPs/kg), followed by the beach mainly used by locals with an average of 234.3 MPs/kg of dry sand (± 140.4 MPs/kg) and the remote beach with an average of 124.4 MPs/kg of dry sand (± 75.1 MPs/kg).
- This is during the high season that the concentrations are the highest with 1189.9 MPs/kg of dry sand (± 786.8 MPs) for the touristic beach of Giardini Naxos, 304.6 MPs/kg of dry sand (± 80.9 MPs/kg) for the beach of Letojanni and 149.3 MPs/kg of dry sand (± 78.8 MPs/kg) for the remote beach of Fondaco Parrino. During the low season, these concentrations are respectively of 536.6 MPs/kg of dry sand (± 431 MPs/kg), 164 MPs/kg of dry sand (± 151.7 MPs/kg) and 99.5 MPs/kg of dry sand (± 62 MPs/kg).
- This is in the middle of the beach that the concentrations of microplastics are the highest with an average of 1371.5 MPs/kg of dry sand (± 669.4 MPs/kg) for the touristic beach, 198.2 MPs/kg of dry sand (± 158.1 MPs/kg) for the beach mainly used by locals and 127.9 MPs/kg of dry sand (± 95.4 MPs/kg) for the remote beach. At the high water mark, the concentrations of microplastics are respectively of 355.1 MPs/kg of dry sand (± 231.3 MPs/kg), 270.3 MPs/kg of dry sand (± 108.8 MPs/kg) and 120.8 MPs/kg of dry sand (± 46.6 MPs/kg).
- The microplastics found in the sand samples are largely dominated by the fibers, including synthetic and non-synthetic fibers, as they represent on average 66.7% (± 28.6%) of all the particles. The fragments represent the second most important category as they account for 22.1% (± 21.3%) of the particles.
- Finally, colored particles are the most abundant (62.6 ± 8.4%) followed by the transparent particles (24 ± 9%), the black particles (10.1 ± 6.1%) and the white particles (3.3 ± 1.3%).

III. Rab

1. Touristic beach: Rajska

a) Characteristics of the beach

The touristic beach of Rajska is a semi-urban beach, located in the municipality of Lopar in the north eastern side of Rab, facing the sea to the SE. It has a total length of ±1000m, a width of ±45m and is composed at 100% of sand with a very smooth slope of 1%. The monitored fixed portion of the beach has a surface of 4476 m^2. The beach is mainly used for recreational activities during the high season (swimming, sunbathing and diving). It is accessible by vehicles and for pedestrians. The area situated

directly behind the beach is a semi-urban area with few services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 44.8240N, 14.7472E (starting point) and 44.8241N, 14.7465E (ending point) (**Fig. 47**). Drink and food outlets are situated directly on the beach and the closest harbor is situated 129km away to the north. The beach is cleaned twice a day from May to October and when necessary during the low season.

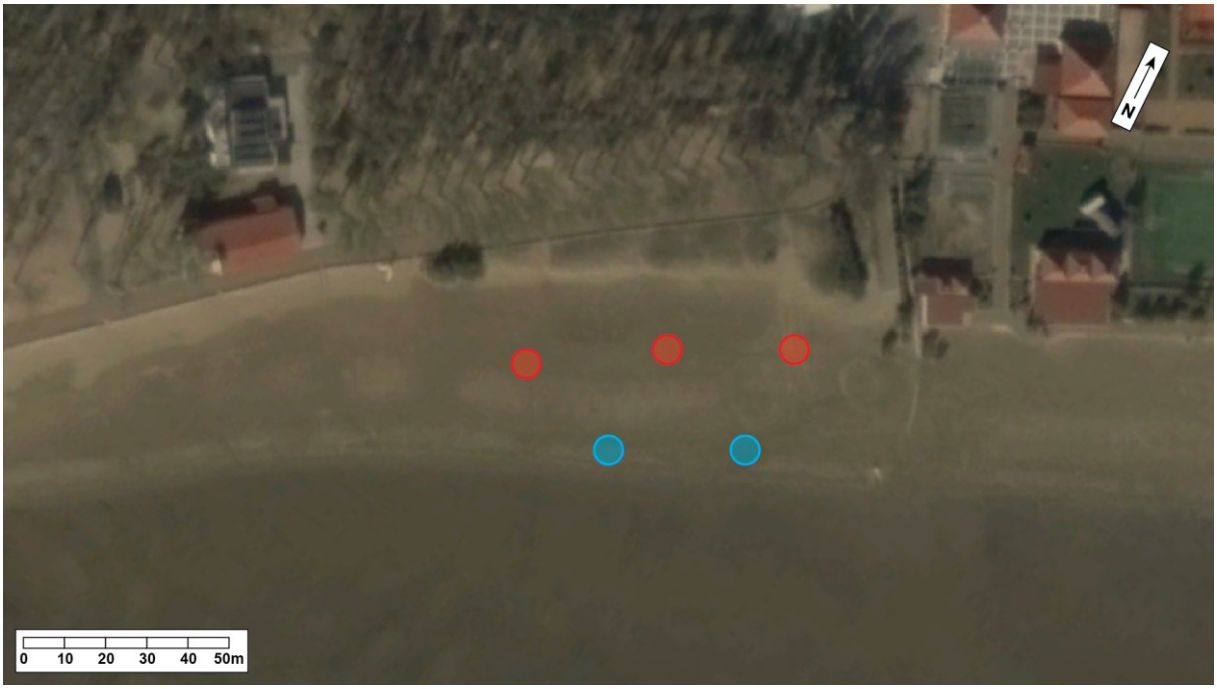

Figure 47: *location map of the sampling sites of the beach of Rajska. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The touristic beach of Rajska was sampled for microplastics in May 2017 (**Fig.48a**), it is then not possible to discuss a possible seasonal variation. The average concentrations is of 563.8 MPs/kg of dry sand (± 73.5 MPs/kg) for the middle of the beach, of 152.6 MPs/kg of dry sand (± 19.9 MPs/kg) for the high water mark and of 358.2 MPs/kg of dry sand (± 46.7 MPs/kg) for the average (**Fig. 48b**).

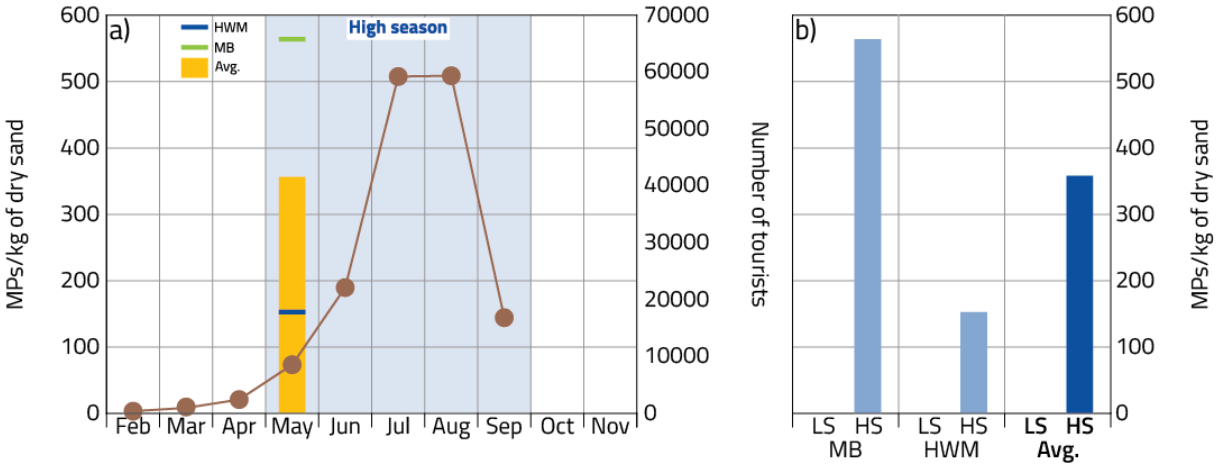

Figure 48: *average concentrations of microplastics for the beach of Rajska. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the*

samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[11] in Rab. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.

c) Types of microplastics

As only one campaign was carried out on the beach of Rajska, it is impossible to discuss the variations between the low and the high season. From the campaign of May, the microplastics are dominated by the fibers, including both synthetic and non-synthetic fibers (HS=52.6%), followed by the films (HS=24.8%), the fragments (HS=16%), the foam (HS=4.9%), the aggregates (HS=0.9%) and the microbeads (HS=0.8%) (**Fig. 49**).

Figure 49: *comparison of the types of microplastics collected in the sand samples of the beach of Rajska. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

As only one campaign was carried out on the beach of Rajska, it is impossible to discuss the variations between the low and the high season. From the campaign of May, the microplastics are dominated by colored particles (Avg=65.3%), followed by the transparent particles (Avg=10.1%), the white particles (Avg=20.5%) and the black particles (Avg=4.2%) (**Fig. 50**).

Figure 50: *comparison of the colors of microplastics collected in the sand samples of the beach of Rajska. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

2. Beach mainly used by locals: Kampor

a) Characteristics of the beach

The beach of Kampor was selected as it is a popular beach mainly used by locals. It is a semi-rural beach, located in the municipality of Kampor in the north western side of Rab, facing the sea to the NW. It has a total length of ±500m, a width ranging from 25m to 50m and is composed at 100% of sand

[11] Data source: monthly number of tourists welcomed on Rab in 2016. From the Rab Tourist Community.

with a smooth slope of 5%. The monitored fixed portion of the beach has a surface of 4389 m^2. The beach is mainly used for recreational activities during the high season (swimming and sunbathing). It is accessible by vehicles and for pedestrians. In the area situated directly behind the beach, very limited services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 44.7854N, 14.7051E (starting point) and 44.7851N, 14.7075E (ending point) (**Fig. 51**). Drink and food outlets are situated directly on the beach and the closest harbor is situated 120 km away to the north. The beach is cleaned once a day from May to September.

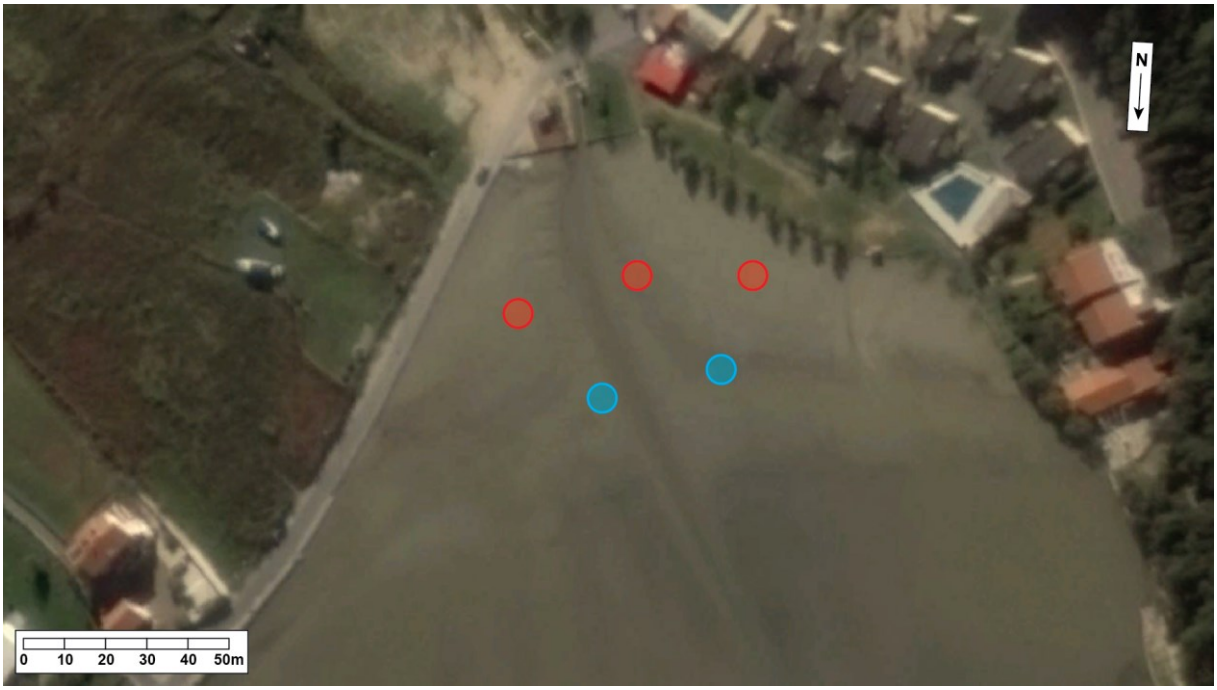

Figure 51: *location map of the sampling sites of the beach of Kampor. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The beach of Kampor, mainly used by locals, was sampled for microplastics in May 2017 (**Fig.52a**), it is then not possible to discuss a possible seasonal variation. The average concentrations is of 371.1 MPs/kg of dry sand (± 48.4 MPs/kg) for the middle of the beach, of 342.3 MPs/kg of dry sand (± 44.6 MPs/kg) for the high water mark and of 356.7 MPs/kg of dry sand (± 46.5 MPs/kg) for the average (**Fig. 52b**).

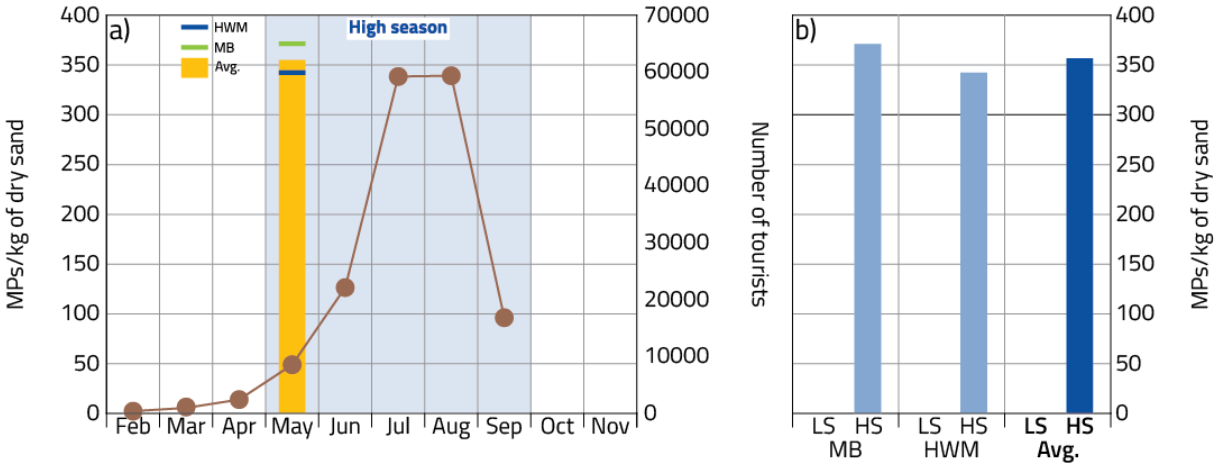

Figure 52: *average concentrations of microplastics for the beach of Kampor. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists*[12] *in Rab. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

As only one campaign was carried out on the beach of Kampor, it is impossible to discuss the variations between the low and the high season. From the campaign of May, the microplastics are dominated by the fibers, including both synthetic and non-synthetic fibers (HS=62.3%), followed by the fragments (HS=34.8%) and the films (HS=2.8%) (**Fig. 53**). No foam, aggregates and microbeads were found.

Figure 53: *comparison of the types of microplastics collected in the sand samples of the beach of Kampor. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

As only one campaign was carried out on the beach of Kampor, it is impossible to discuss the variations between the low and the high season. From the campaign of May, the microplastics are dominated by colored particles (Avg=83.7%), followed by the transparent particles (Avg=8.3%) and the black particles (Avg=8%) (**Fig. 54**). No white particles were found.

[12] Data source: monthly number of tourists welcomed on Rab in 2016. From the Rab Tourist Community.

Figure 54: *comparison of the colors of microplastics collected in the sand samples of the beach of Kampor. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

3. Remote beach: Pudarica

a) Characteristics of the beach

The remote beach of Pudarica is a rural beach, located in the municipality of Barbat na Rabu in the south western side of Rab, facing the sea to the SW. It has a total length of ±150m, a width of ±10m and is composed at 90% of sand and 10% of rocks with a very smooth slope of 1%. The monitored fixed portion of the beach has a surface of 1055 m^2. The beach is mainly used for recreational activities during the high season (swimming, sunbathing, fishing and diving) and the low season (fishing). It is only accessible for pedestrians. The area situated directly behind the beach is a rural area with very limited services and facilities provided to the beach users (only 1 beach club). The coordinates of the fixed 100m portion selected for the monitoring are: 44.7076N, 14.8318E (starting point) and 44.7074N, 14.8311E (ending point) (**Fig. 55**). The closest harbor is situated 116km away to the north. The beach is cleaned once a day from May to October.

Figure 55: *location map of the sampling sites of the beach of Pudarica. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The remote beach of Pudarica was sampled for microplastics in May 2017 (**Fig.56a**), it is then not possible to discuss a possible seasonal variation. The average concentrations is of 886.1 MPs/kg of dry sand (± 115.5 MPs/kg) for the middle of the beach, of 162.6 MPs/kg of dry sand (± 21.2 MPs/kg) for the high water mark and of 524.3 MPs/kg of dry sand (± 68.3 MPs/kg) for the average (**Fig. 56b**).

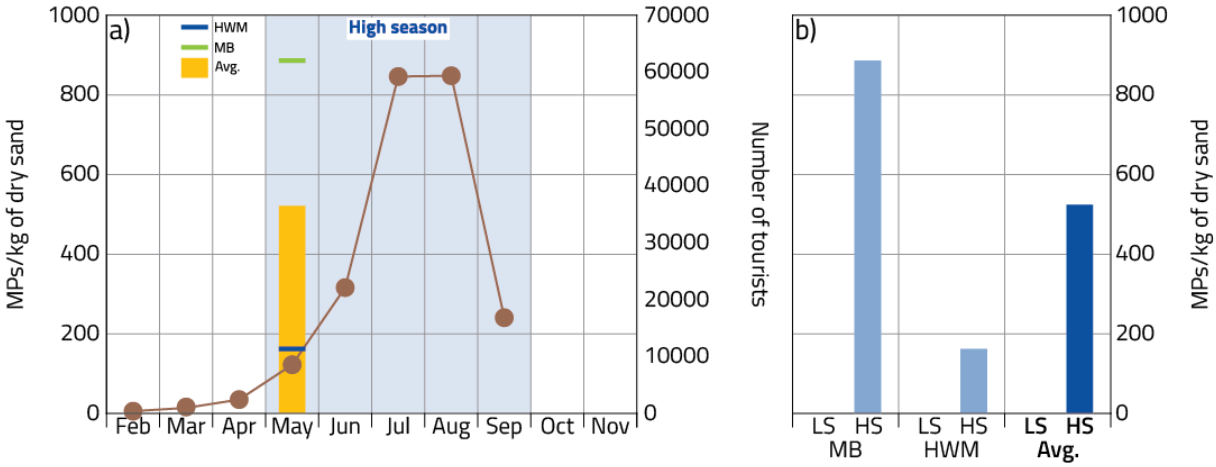

Figure 56: *average concentrations of microplastics for the beach of Pudarica. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[13] in Rab. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

As only one campaign was carried out on the beach of Pudarica, it is impossible to discuss the variations between the low and the high season. From the campaign of May, the microplastics are dominated by the fibers, including both synthetic and non-synthetic fibers (HS=65.2%), followed by the fragments (HS=23.2%), the films (HS=7.4%) and the foam (HS=4.3%) (**Fig. 57**). No aggregate and microbeads were found.

Figure 57: *comparison of the types of microplastics collected in the sand samples of the beach of Pudarica. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of the microplastics

As only one campaign was carried out on the beach of Pudarica, it is impossible to discuss the variations between the low and the high season. From the campaign of May, the microplastics are dominated by

[13] Data source: monthly number of tourists welcomed on Rab in 2016. From the Rab Tourist Community.

colored particles (Avg=77.4%), followed by the transparent particles (Avg=21.6%) and the black particles (Avg=1%) (**Fig. 58**). No white particles were found.

Figure 58: *comparison of the colors of microplastics collected in the sand samples of the beach of Pudarica. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

4. Summary

The 3 campaigns of sand sampling conducted on 3 beaches of Rab in 2017 have revealed that the sand of all the monitored beaches is contaminated with microplastics:

- This is on the remote beach that the concentrations of microplastics are the highest with an average of 524.3 MPs/kg of dry sand (± 361.8 MPs/kg), followed by the touristic beach with an average of 358.2 MPs/kg of dry sand (± 205.6 MPs/kg) and the beach mainly used by locals with an average of 356.7 MPs/kg of dry sand (± 14.4 MPs/kg).
- This is in the middle of the beach that the concentrations of microplastics are the highest with an average of 563.8 MPs/kg of dry sand for the touristic beach, 371.1 MPs/kg of dry sand for the beach mainly used by locals and 886.1 MPs/kg of dry sand for the remote beach. At the high water mark, the concentrations of microplastics are respectively of 152.6 MPs/kg of dry sand, 342.3 MPs/kg of dry sand and 162.6 MPs/kg of dry sand.
- The microplastics found in the sand samples are largely dominated by the fibers, including synthetic and non-synthetic fibers, as they represent on average 60% (± 7.7%) of all the particles. The fragments represent the second most important category as they account for 24.7% (± 9.2%) of the particles.
- Finally, coloured particles are the most abundant (75.5 ± 7.7%) followed by the transparent particles (13.3 ± 5.9%), the black particles (4.4 ± 2.9%) and the white particles (6.8 ± 9.7%).

IV. Malta

1. Touristic beach: Golden Bay

a) Characteristics of the beach

The touristic beach of Golden Bay is a semi-urban beach, located in the municipality of Il-Mellieħa in the north western side of Malta, facing the sea to the SW. It has a total length of ±230m, a width of ±44m and is composed at 90% of sand and 10% of pebbles with a slope of 26.8%. The monitored fixed portion of the beach has a surface of 3230 m^2. The beach is mainly used for recreational activities during the high season (swimming, sunbathing and barbecues) and the low season (sunbathing). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach, has

many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 35.9334N, 14.3448E (starting point) and 35.9341N, 14.3444E (ending point) (**Fig. 59**). Drink and food outlets are situated directly on the beach and the closest harbor is situated 6 km away to the north. The beach is cleaned once a day all year long.

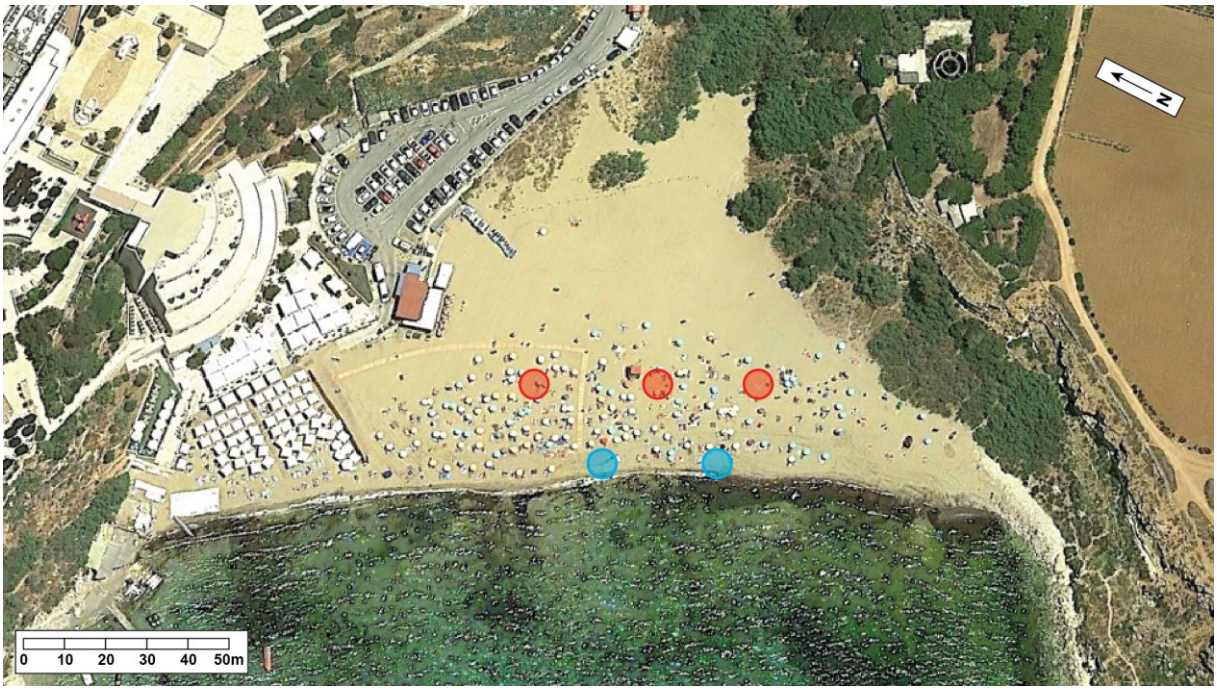

Figure 59: *location map of the sampling sites of the beach of Golden Bay. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The touristic beach of Golden Bay was sampled for microplastics in March, June, September and November of 2017 (**Fig. 60**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in November (255.9 MPs/kg of dry sand ± 33.3 MPs/kg), while the highest averaged concentration is observed in June (4321.8 MPs/kg of dry sand ± 563.1 MPs/kg) (**Fig. 60a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in November (56.9 MPs/kg of dry sand ± 7.4 MPs/kg) and the highest in March (511.8 MPs/kg of dry sand ± 66.7 MPs/kg) (**Fig. 60a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in November (156.4 MPs/kg of dry sand ± 99.5 MPs/kg) and the highest in June (2331.5 MPs/kg of dry sand ± 1990.3 MPs/kg) (**Fig. 60a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Malta: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 60a**). During the low season the average concentrations is of 540.2 MPs/kg of dry sand (± 284.3 MPs/kg) for the middle of the beach, of 284.3 MPs/kg of dry sand (± 227.5 MPs/kg) for the high water mark and of 412.3 MPs/kg of dry sand (± 255.9 MPs/kg) for the average (**Fig. 60b**). During the high season the average concentrations is of 3824.2 MPs/kg of dry sand (± 497.6 MPs/kg) for the middle of the beach, of 255.9 MPs/kg of dry sand (± 85.3 MPs/kg) for the high water mark and of 2040.1 MPs/kg of dry sand (± 291.4 MPs/kg) for the average (**Fig. 60b**). The concentrations are higher during the high season for the samples from the middle of the beach and lower for the samples from the high water mark. Finally an average increase

of +394.8% of the concentrations of microplastics is observed from the low to the high season (**Fig. 60b**).

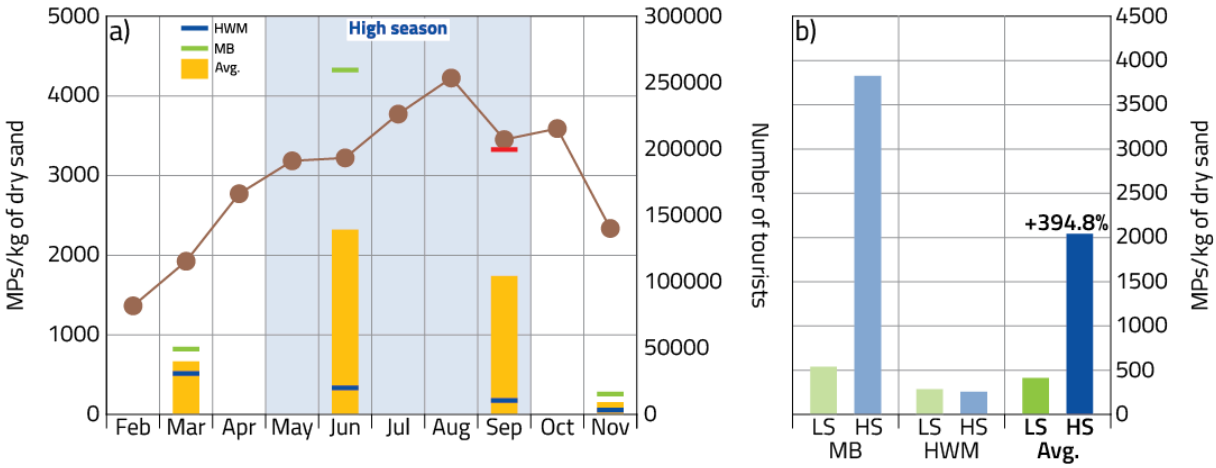

Figure 60: *average concentrations of microplastics for the beach of Golden Bay. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[14] in Malta. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Golden Bay are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=66.8% ±28.6%; LS=61.5% and HS=72.1%), followed by the fragments (Avg=30.8% ±29.3%; LS=37.3% and HS=24.3%), the films (Avg=2.1% ±3%; LS=1.2% and HS=3.1%), the aggregates (Avg=0.2% ±0.4%; LS=0% and HS=0.3%) and the foam (Avg=0.1% ±0.2%; LS=0% and HS=0.2%). No microbeads were found. The proportion of fibers is higher during the high season compared to the low season (**Fig. 61**).

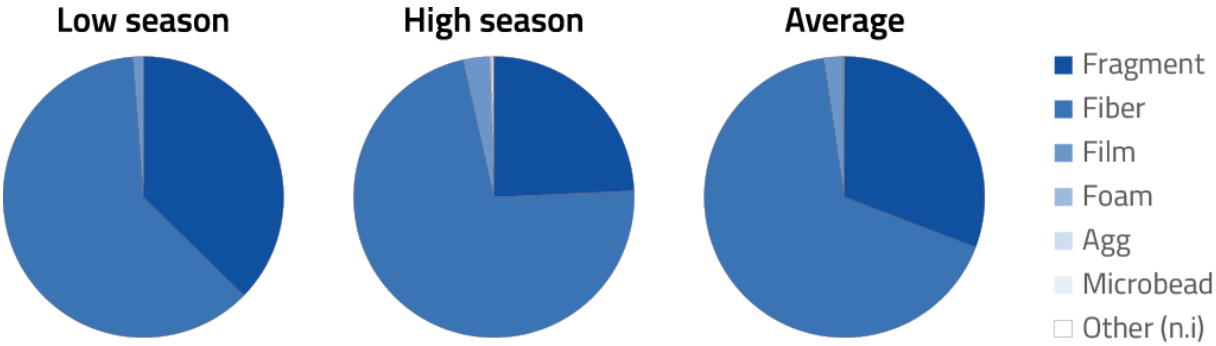

Figure 61: *comparison of the types of microplastics collected in the sand samples of the beach of Golden Bay. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Golden Bay are dominated by colored particles (Avg=72.5% ±1%; LS=73.3% and HS=71.8%), followed by the black particles (Avg=14% ±4.1%; LS=16.9% and HS=11.1%), the transparent particles (Avg=11.1% ±1.9%; LS=9.8% and

[14] Data source: monthly number of tourists welcomed on Malta in 2016, Malta Tourism Authority: http://www.mta.com.mt/

HS=12.5%), and the white particles (Avg=2.3% ±3.3%; LS=0% and HS=4.6%). The proportion of colored particles is lower during the high season compared to the low season (**Fig. 62**).

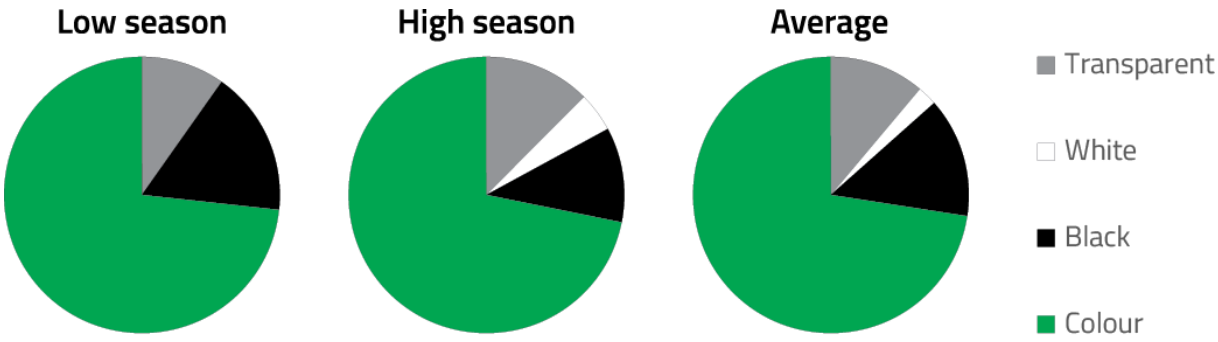

Figure 62: *comparison of the colors of microplastics collected in the sand samples of the beach of Golden Bay. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

2. Beach mainly used by locals: Gnejna Bay

a) Characteristics of the beach

The beach of Gnejna was selected as it is a popular beach mainly used by locals. It is a semi-rural beach, located in the municipality of L-Imġarr in the north western side of Malta, facing the sea to the NW. It has a total length of 204m, a width of 52m and is composed at 95% of sand and 5% of pebbles with a slope of 36.4%. The monitored fixed portion of the beach has a surface of 3187 m^2. The beach is mainly used for recreational activities during the high season (swimming, sunbathing and barbecues). It is accessible by vehicles/boats and for pedestrians. In the area situated directly behind the beach, very limited services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 35.9207N, 14.3439E (starting point) and 35.9204N, 14.3429E (ending point) (**Fig. 63**). Drink and food outlets are situated directly on the beach and the closest harbor is situated 8 km away to the north. The beach is cleaned once a day all year long.

Figure 63: *location map of the sampling sites of the beach of Gnejna. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The beach of Gnejna, mainly used by locals, was sampled for microplastics in March, June, September and November of 2017 (**Fig. 64**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in November (85.3 MPs/kg of dry sand ± 11.1 MPs/kg), while the highest averaged concentration is observed in June (12595.8 MPs/kg of dry sand ± 1641.2 MPs/kg) (**Fig. 64a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in June (85.3 MPs/kg of dry sand ± 11.1 MPs/kg) and the highest in March (199 MPs/kg of dry sand ± 25.9 MPs/kg) (**Fig. 64a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in November (127.9 MPs/kg of dry sand ± 42.6 MPs/kg) and the highest in June (6340.6 MPs/kg of dry sand ± 6255.3 MPs/kg) (**Fig. 64a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Malta: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 64a**). During the low season the average concentrations is of 312.8 MPs/kg of dry sand (± 227.5 MPs/kg) for the middle of the beach, of 184.8 MPs/kg of dry sand (± 14.2 MPs/kg) for the high water mark and of 248.8 MPs/kg of dry sand (± 120.8 MPs/kg) for the average (**Fig. 64b**). During the high season the average concentrations is of 6767 MPs/kg of dry sand (± 5828.8 MPs/kg) for the middle of the beach, of 127.9 MPs/kg of dry sand (± 42.6 MPs/kg) for the high water mark and of 3447.5 MPs/kg of dry sand (± 2893.1 MPs/kg) for the average (**Fig. 64b**). The concentrations are higher during the high season for the samples from the middle of the beach and lower for the samples from the high water mark. Finally an average increase of +1285.7% of the concentrations of microplastics is observed from the low to the high season (**Fig. 64b**).

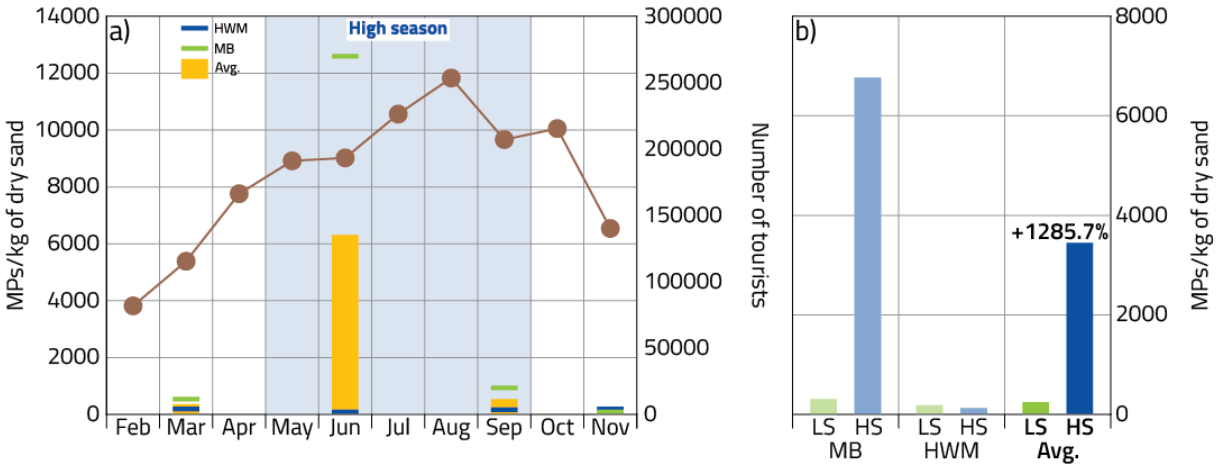

Figure 64: *average concentrations of microplastics for the beach of Gnejna. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[15] in Malta. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

[15] Data source: monthly number of tourists welcomed on Malta in 2016, Malta Tourism Authority: http://www.mta.com.mt/

c) Types of microplastics

On average the microplastics extracted from the sand of beach of Gnejna are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=55.3% ±23%; LS=54.5% and HS=56.1%), followed by the fragments (Avg=33.1% ±23.9%; LS=26.2% and HS=40.1%), the films (Avg=6.9% ±11.7%; LS=13% and HS=0.7%), the foam (Avg=2.8% ±5.9%; LS=4.2% and HS=1.5%), the microbeads (Avg=1.1% ±3.1%; LS=2.2% and HS=0%) and the aggregates (Avg=0.7% ±2.1%; LS=0% and HS=1.5%). The proportion of fibers and fragments is higher during the high season compared to the low season (**Fig. 65**).

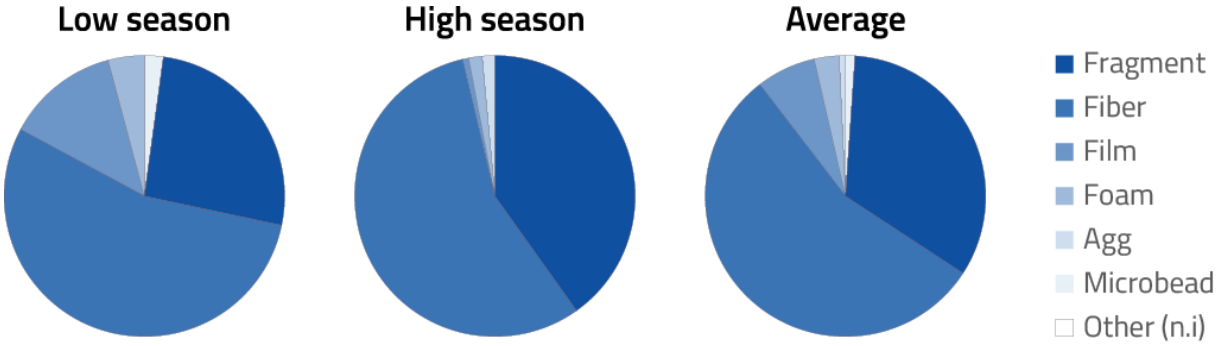

Figure 65: *comparison of the types of microplastics collected in the sand samples of the beach of Gnejna. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Gnejna are dominated by colored particles (Avg=61% ±20.7%; LS=46.4% and HS=75.7%), followed by the transparent particles (Avg=17.8% ±6.4%; LS=22.3% and HS=13.2%), the white particles (Avg=12.5% ±14.5%; LS=22.8% and HS=2.3%) and the black particles (Avg=8.6% ±0.1%; LS=8.6% and HS=8.7%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 66**).

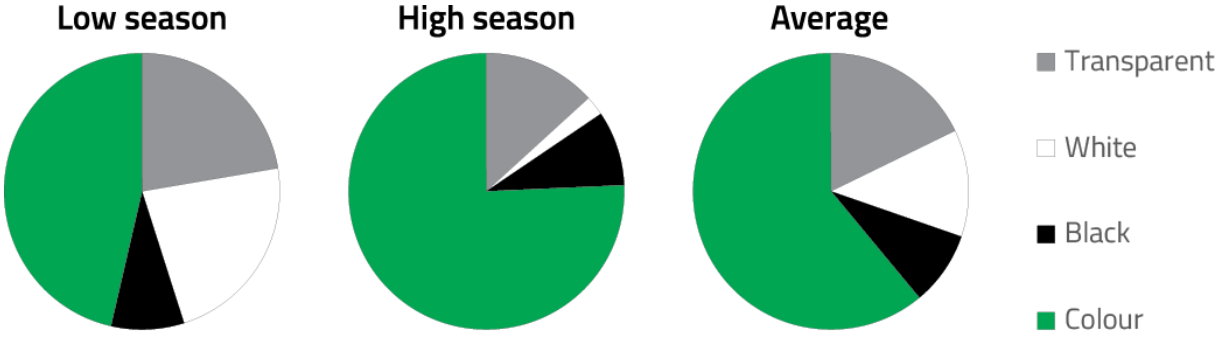

Figure 66: *comparison of the colors of microplastics collected in the sand samples of the beach of Gnejna. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

3. Remote beach: Marsaxlokk

a) Characteristics of the beach

The term “remote” to characterize the beach of Marsaxlokk is questionable as it is a semi-urban beach, located in the municipality of Marsaxlokk in the south eastern side of Malta, facing the sea to the south. It has a total length of 216m, a width ranging from 6 to 16m and is composed at 65% of sand and 35% of pebbles with a slope of 46.6%. The monitored fixed portion of the beach has a surface of 1061 m^2. The beach is mainly used for recreational activities during the high season (sunbathing, fishing and barbecues) and the low season (fishing). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach, has few services and facilities provided to the beach users.

The coordinates of the fixed 100m portion selected for the monitoring are: 35.8387N, 14.5491E (starting point) and 35.8391N, 14.5482E (ending point) (**Fig. 67**). The closest harbor is situated 0.02 km away to the NW. The beach is cleaned once every 2 days all year long.

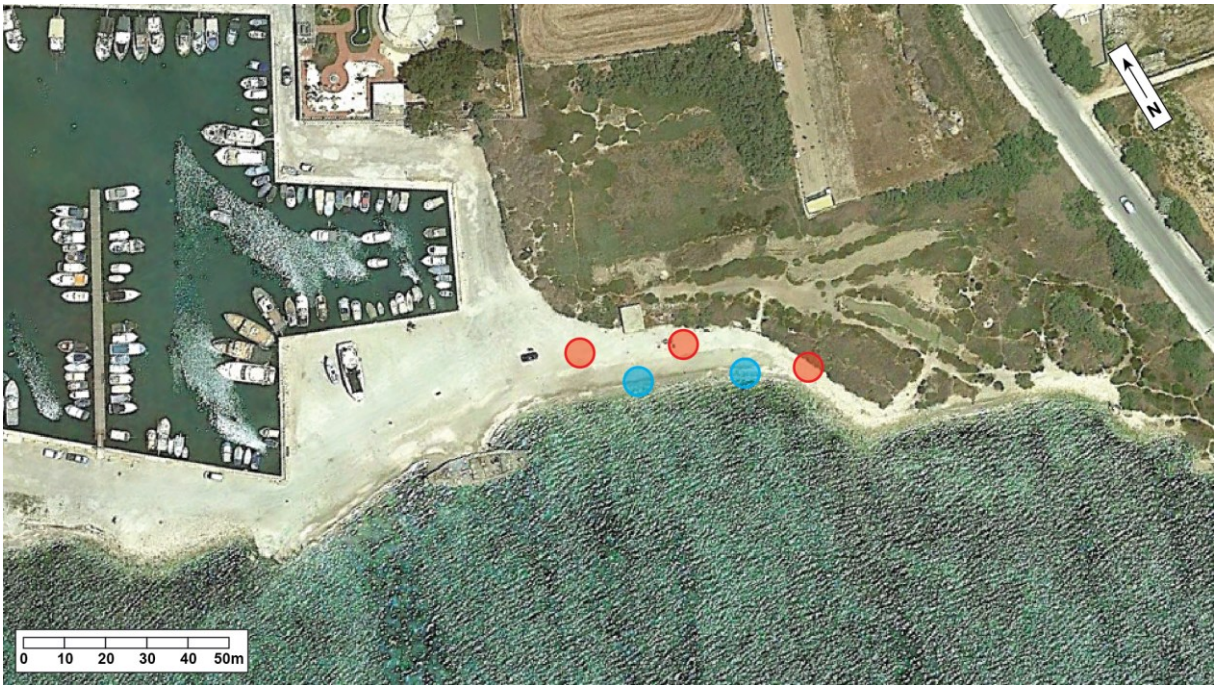

Figure 67: *location map of the sampling sites of the beach of Marsaxlokk. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The remote beach of Marsaxlokk was sampled for microplastics in March, June, September and November of 2017 (**Fig. 68**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in November (28.4 MPs/kg of dry sand ± 3.7 MPs/kg), while the highest averaged concentration is observed in March (483.4 MPs/kg of dry sand ± 63 MPs/kg) (**Fig. 68a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in September (56.9 MPs/kg of dry sand ± 7.4 MPs/kg) and the highest in June (426.5 MPs/kg of dry sand ± 55.6 MPs/kg) (**Fig. 68a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in November (56.9 MPs/kg of dry sand ± 28.4 MPs/kg) and the highest in March (383.8 MPs/kg of dry sand ± 99.5 MPs/kg) (**Fig. 68a**, yellow bars). No seasonal variations are observed for the concentrations of microplastics when compared to the average number of tourists welcomed to Malta (**Fig. 68a**). During the low season the average concentrations is of 255.9 MPs/kg of dry sand (± 227.5 MPs/kg) for the middle of the beach, of 184.8 MPs/kg of dry sand (± 99.5 MPs/kg) for the high water mark and of 220.4 MPs/kg of dry sand (± 163.5 MPs/kg) for the average (**Fig. 68b**). During the high season the average concentrations is of 142.2 MPs/kg of dry sand (± 28.4 MPs/kg) for the middle of the beach, of 241.7 MPs/kg of dry sand (± 184.8 MPs/kg) for the high water mark and of 191.9 MPs/kg of dry sand (± 78.2 MPs/kg) for the average (**Fig. 68b**). The concentrations are higher during the high season for the samples from the high water mark and lower for the samples from the middle of the beach. Finally an average decrease of -12.9% of the concentrations of microplastics is observed from the low to the high season (**Fig. 68b**).

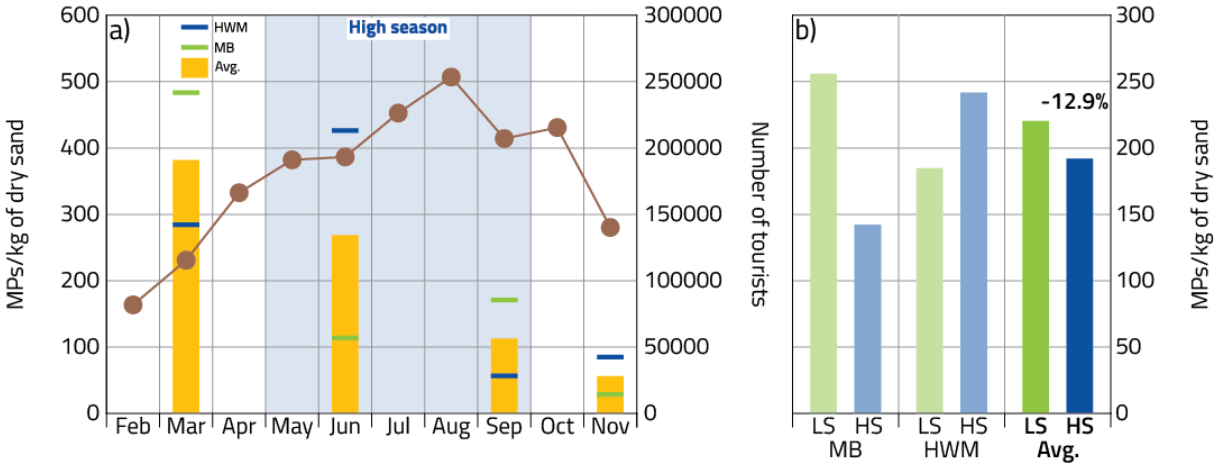

Figure 68: *average concentrations of microplastics for the beach of Marsaxlokk. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[16] in Malta. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Marsaxlokk are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=64.1% ±34%; LS=91.5% and HS=36.7%), followed by the fragments (Avg=27.2% ±34.2%; LS=3.6% and HS=50.8%), the foam (Avg=4.6% ±9.6%; LS=2.6% and HS=6.7%) and the films (Avg=4.1% ±6.3%; LS=2.3% and HS=5.8%). No aggregates and microbeads were found. The proportion of fragments is higher during the high season compared to the low season (**Fig. 69**).

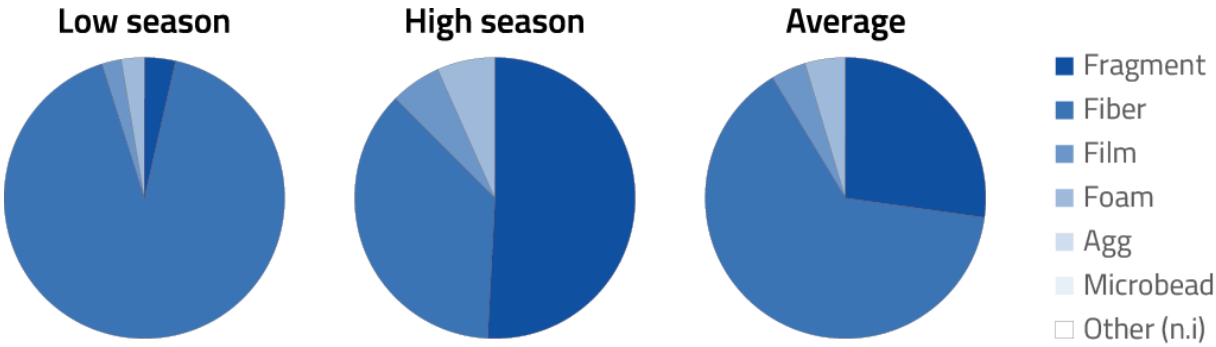

Figure 69: *comparison of the types of microplastics collected in the sand samples of the beach of Marsaxlokk. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Marsaxlokk are dominated by colored particles (Avg=72.4% ±11.9%; LS=64% and HS=80.8%), followed by the black particles (Avg=20.1% ±13.1%; LS=29.3% and HS=10.8%), the white particles (Avg=4.1% ±3.7%; LS=1.5% and HS=6.7%) and the transparent particles (Avg=3.4% ±2.5%; LS=5.2% and HS=1.7%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 70**).

[16] Data source: monthly number of tourists welcomed on Malta in 2016, Malta Tourism Authority: http://www.mta.com.mt/

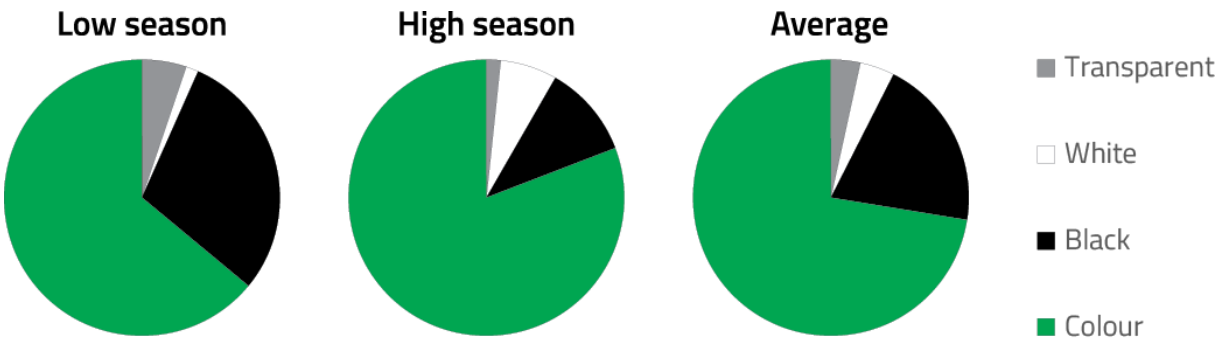

Figure 70: *comparison of the colors of microplastics collected in the sand samples of the beach of Marsaxlokk. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

4. Summary

The 12 campaigns of sand sampling conducted on 3 beaches of Malta in 2017 have revealed that the sand of all the monitored beaches is contaminated with microplastics:

- This is on the beach mainly used by locals that the concentrations of microplastics are the highest with an average of 1848.1 MPs/kg of dry sand (± 4071.5 MPs/kg), followed by the touristic beach with an average of 1226.2 MPs/kg of dry sand (± 1535.9 MPs/kg) and the remote beach with an average of 206.1 MPs/kg of dry sand (± 161.9 MPs/kg).
- This is during the high season that the concentrations are the highest with 2040.1 MPs/kg of dry sand (± 1819.5 MPs) for the touristic beach of Golden Bay, 3447.5 MPs/kg of dry sand (± 5292.2 MPs/kg) for the beach of Gnejna and 191.9 MPs/kg of dry sand (± 141.3 MPs/kg) for the remote beach of Marsaxlokk. During the low season, these concentrations are respectively of 412.3 MPs/kg of dry sand (± 287.5 MPs/kg), 248.8 MPs/kg of dry sand (± 173.4 MPs/kg) and 220.4 MPs/kg of dry sand (± 179.1 MPs/kg).
- This is in the middle of the beach that the concentrations of microplastics are the highest with an average of 2182.2 MPs/kg of dry sand (± 1691.3 MPs/kg) for the touristic beach, 3539.9 MPs/kg of dry sand (± 5237.1 MPs/kg) for the beach mainly used by locals and 199 MPs/kg of dry sand (± 171.8 MPs/kg) for the remote beach. At the high water mark, the concentrations of microplastics are respectively of 270.1 MPs/kg of dry sand (± 172.4 MPs/kg), 156.4 MPs/kg of dry sand (± 42.6 MPs/kg) and 213.2 MPs/kg of dry sand (± 151.1 MPs/kg).
- The microplastics found in the sand samples are largely dominated by the fibers, including synthetic and non-synthetic fibers, as they represent on average 55% (± 25.2%) of all the particles. The fragments represent the second most important category as they account for 38.4% (± 27%) of the particles.
- Finally, colored particles are the most abundant (68.7 ± 5.4%) followed by the black particles (14.2 ± 4.7%), the transparent particles (10.8 ± 5.9%) and the white particles (6.3 ± 4.5%).

V. Crete

1. Touristic beach: Rethymno

a) Characteristics of the beach

The touristic beach of Rethymno is an urban beach, located in the municipality of Rethymno in the central north western side of Crete, facing the sea to the NE. It has a total length of ±450m, a width of ±36m and is composed at 100% of sand with a smooth slope of 3%. The monitored fixed portion of the

beach has a surface of 2531 m^2. It has a pier situated on each sides. The beach is mainly used for recreational activities during the high season (swimming, sunbathing and local people) and the low season (local people). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach, has many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 35.3694N, 24.4771E (starting point) and 35.3686N, 24.4776E (ending point) (**Fig. 71**). Drink and food outlets are situated directly on the beach and harbors can be found on each side of the beach. The beach is cleaned once a week all year long.

Figure 71: *location map of the sampling sites of the beach of Rethymno. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The touristic beach of Rethymno was sampled for microplastics in March, June, September and November of 2017 (**Fig. 72**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in November (26.9 MPs/kg of dry sand ± 3.5 MPs/kg), while the highest averaged concentration is observed in September (1506.9 MPs/kg of dry sand ± 196.4 MPs/kg) (**Fig. 72a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in September (28.3 MPs/kg of dry sand ± 3.7 MPs/kg) and the highest in March (372.1 MPs/kg of dry sand ± 48.5 MPs/kg) (**Fig. 72a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in November (141.4 MPs/kg of dry sand ± 114.5 MPs/kg) and the highest in September (767.6 MPs/kg of dry sand ± 739.3 MPs/kg) (**Fig. 72a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Crete: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 72a**). During the low season the average concentrations is of 136.5 MPs/kg of dry sand (± 109.6 MPs/kg) for the middle of the beach, of 314 MPs/kg of dry sand (± 58.1 MPs/kg) for the high water mark and of 225.3 MPs/kg of dry sand (± 83.9 MPs/kg) for the average (**Fig. 72b**). During the high season the average concentrations is of 1019.9 MPs/kg of dry sand (± 487 MPs/kg) for the middle of the beach, of 53.3

MPs/kg of dry sand (± 25 MPs/kg) for the high water mark and of 536.6 MPs/kg of dry sand (± 231 MPs/kg) for the average (**Fig. 72b**). The concentrations are higher during the high season for the samples from the middle of the beach and lower for the samples from the high water mark. Finally an average increase of +138.2% of the concentrations of microplastics is observed from the low to the high season (**Fig. 72b**).

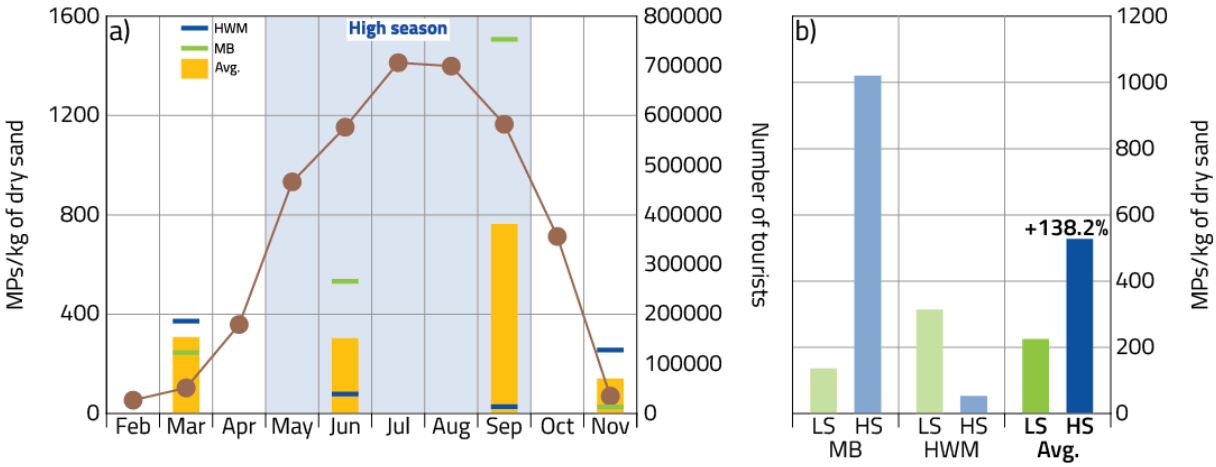

Figure 72: *average concentrations of microplastics for the beach of Rethymno. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[17] in Crete. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Rethymno are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=77.2% ±27.2%; LS=86.4% and HS=68%), followed by the fragments (Avg=17.9% ±23.6%; LS=6.8% and HS=29%), the foam (Avg=2% ±3.4%; LS=2.3% and HS=1.7%), the films (Avg=1.6% ±3.3%; LS=2.3% and HS=0.9%), the microbeads (Avg=0.2% ±0.6%; LS=0% and HS=0.4%) and the particles not identified but suspected to be microplastics (Avg=1.1% ±3.2%; LS=2.3% and HS=0%). No aggregates were found. The proportion of fragments is higher during the high season compared to the low season (**Fig. 73**).

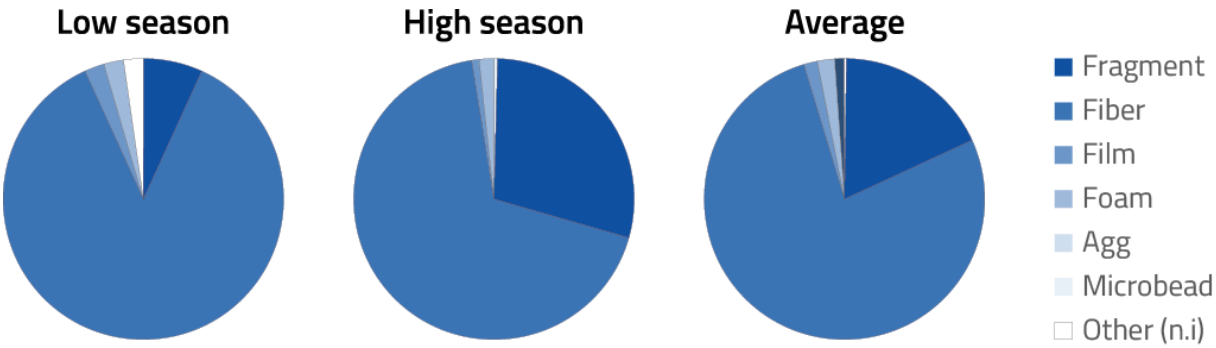

Figure 73: *comparison of the types of microplastics collected in the sand samples of the beach of Rethymno. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

[17] Data source: monthly number of tourists welcomed in Crete in 2016.

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Rethymno are dominated by colored particles (Avg=69.5% ±26.2%; LS=50.9% and HS=88%), followed by the black particles (Avg=21.8% ±23%; LS=38.1% and HS=5.5%), the transparent particles (Avg=5.4% ±1.5%; LS=6.4% and HS=4.4%) and the white particles (Avg=3.3% ±1.7%; LS=4.5% and HS=2.1%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 74**).

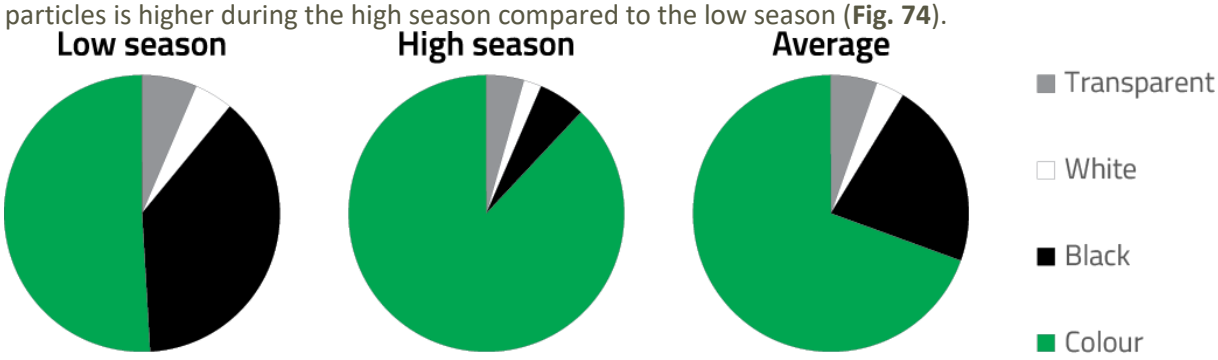

Figure 74: *comparison of the colors of microplastics collected in the sand samples of the beach of Rethymno. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

2. Beach mainly used by locals: Arina

a) Characteristics of the beach

The beach of Arina was selected as it is a popular beach mainly used by locals. It is a semi-urban beach, located in the municipality of Vathianos Kampos in the central north eastern side of Crete, facing the sea to the north. It has a total length of ±455m, a width of ±75m and is composed at 100% of sand with a smooth slope of 2%. The monitored fixed portion of the beach has a surface of 3173 m^2. The beach is mainly used for recreational activities all year long (swimming, sunbathing and local people). It is accessible by vehicles and for pedestrians. In the area situated directly behind the beach, few services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 35.3310N, 25.2391E (starting point) and 35.3314N, 25.2401E (ending point) (**Fig. 75**). Drink and food outlets are situated directly on the beach and the closest harbor is situated 8 km away to the west. The beach is cleaned once a day from April to October.

Figure 75: *location map of the sampling sites of the beach of Arina. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The beach of Arina, mainly used by locals, was sampled for microplastics in March, June, September and November of 2017 (**Fig. 76**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in March (85.7 MPs/kg of dry sand ± 11.2 MPs/kg), while the highest averaged concentration is observed in September (1004.5 MPs/kg of dry sand ± 130.9 MPs/kg) (**Fig. 76a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in November as no microplastics were found and the highest in September (1393.2 MPs/kg of dry sand ± 181.5 MPs/kg) (**Fig. 76a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in March (70.7 MPs/kg of dry sand ± 15 MPs/kg) and the highest in September (1198.9 MPs/kg of dry sand ± 194.4 MPs/kg) (**Fig. 76a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Crete: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 76a**). During the low season the average concentrations is of 169.9 MPs/kg of dry sand (± 84.2 MPs/kg) for the middle of the beach, of 27.8 MPs/kg of dry sand (± 27.8 MPs/kg) for the high water mark and of 98.9 MPs/kg of dry sand (± 28.2 MPs/kg) for the average (**Fig. 76b**). During the high season the average concentrations is of 1004.5 MPs/kg of dry sand (± 130.9 MPs/kg) for the middle of the beach, of 867.2 MPs/kg of dry sand (± 526 MPs/kg) for the high water mark and of 770 MPs/kg of dry sand (± 428.8 MPs/kg) for the average (**Fig. 76b**). The concentrations are always higher during the high season, no matter the origin of the sample. Finally an average increase of +678.8% of the concentrations of microplastics is observed from the low to the high season (**Fig. 76b**).

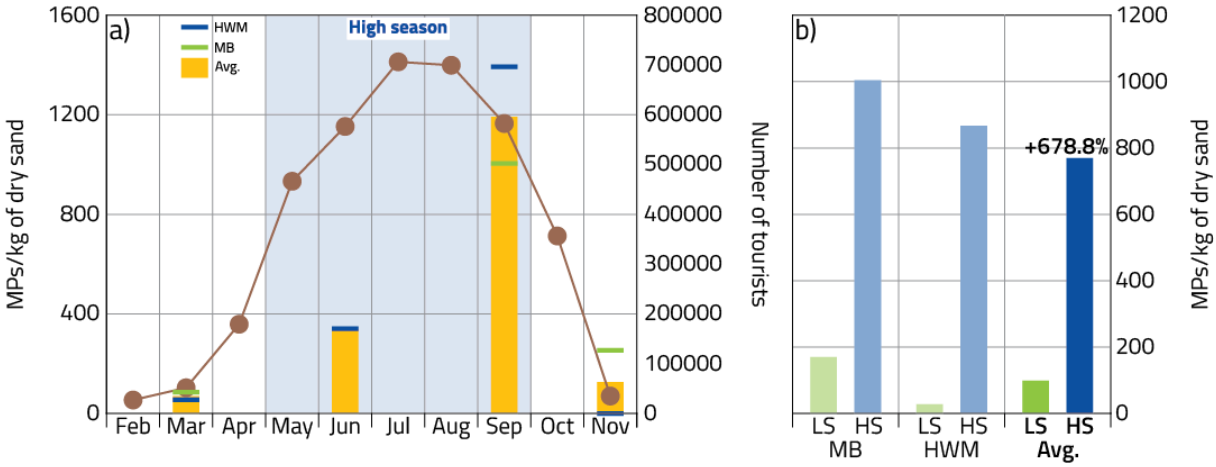

Figure 76: *average concentrations of microplastics for the beach of Arina. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples in Crete. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Arina are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=89% ±11.5%; LS=85.6% and HS=92.4%), followed by the fragments (Avg=10.6% ±11.8%; LS=14.4% and HS=6.7%), the aggregates (Avg=0.5% ±1.1%; LS=0% and HS=0.9%). No films, foam and microbeads were found. The proportion of fibers is higher during the high season compared to the low season (**Fig. 77**).

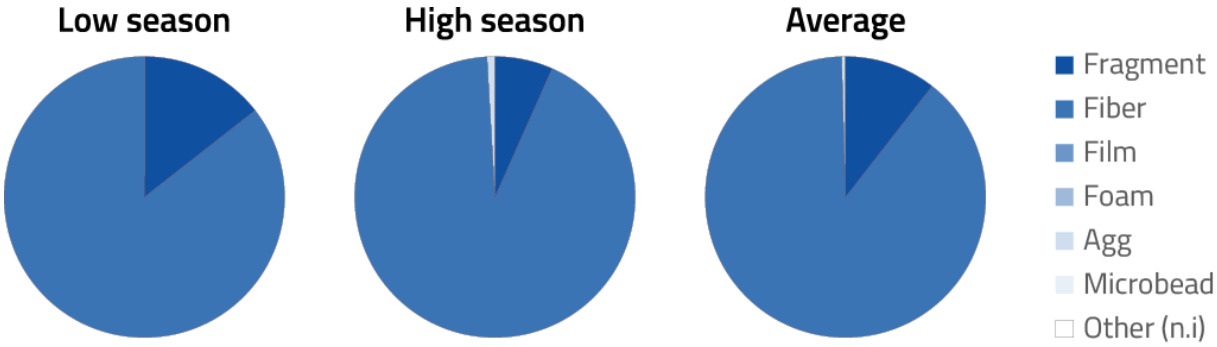

Figure 77: *comparison of the types of microplastics collected in the sand samples of the beach of Arina. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of the microplastics

On average the microplastics extracted from the sand of the beach of Arina are dominated by colored particles (Avg=66.9% ±27.9%; LS=86.7% and HS=47.1%), followed by the transparent particles (Avg=23.2% ±32.9%; LS=0% and HS=46.5%) and the black particles (Avg=9.9% ±4.9%; LS=13.3% and HS=6.4%). No white particles were found. The proportion of colored particles is lower during the high season compared to the low season (**Fig. 78**).

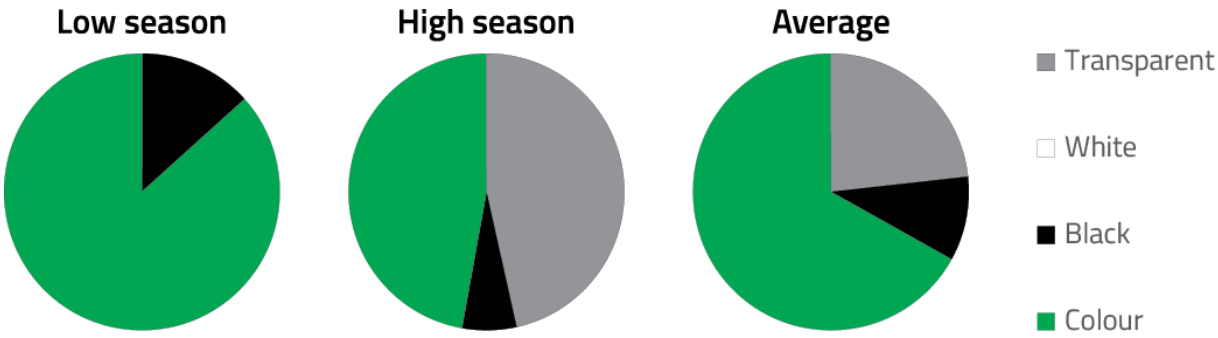

Figure 78: *comparison of the colors of microplastics collected in the sand samples of the beach of Arina. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

3. Remote beach: Tsoutsouras

a) Characteristics of the beach

The remote beach of Tsoutsouras is a rural beach, located in the municipality of Tsoutsouras Krasas in the central south eastern side of Crete, facing the sea to the south. It has a total length of ±460m, a width ranging from 20m to 35m and is composed at 100% of coarse sand with a slope of 11%. The monitored fixed portion of the beach has a surface of 2541 m^2. The beach is mainly used for recreational activities during the high season (swimming and sunbathing). It is only accessible for pedestrians. The area situated directly behind the beach is a rural area with no services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 34.9838N, 25.3053E (starting point) and 34.9842N, 25.3043E (ending point) (**Fig. 79**). The closest harbor is situated 38 km away to the east. No cleaning activities are conducted on the beach.

Figure 79: *location map of the sampling sites of the beach of Tsoutsouras. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The remote beach of Tsoutsouras was sampled for microplastics in March, June, September and November of 2017 (**Fig. 80**). The lowest averaged concentration of microplastics extracted from the

samples collected at the middle of the beaches is observed in November as no microplastics were found, while the highest averaged concentration is observed in March (55.4 MPs/kg of dry sand ± 7.2 MPs/kg) (**Fig. 80a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in November (113.7 MPs/kg of dry sand ± 14.8 MPs/kg) and the highest in March (341.2 MPs/kg of dry sand ± 44.5 MPs/kg) (**Fig. 80a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in November (56.9 MPs/kg of dry sand ± 56.9 MPs/kg) and the highest in June (255.9 MPs/kg of dry sand ± 33.3 MPs/kg) (**Fig. 80a**, yellow bars). The clear seasonal variation is observed for the concentrations of microplastics when compared to the average number of tourists welcomed Crete. This is probably due to the high concentrations measured in March (**Fig. 80a**). During the low season the average concentrations is of 27.7 MPs/kg of dry sand (± 27.7 MPs/kg) for the middle of the beach, of 227.5 MPs/kg of dry sand (± 113.7 MPs/kg) for the high water mark and of 127.6 MPs/kg of dry sand (± 70.7 MPs/kg) for the average (**Fig. 80b**). During the high season the average concentrations is of 0 MPs/kg of dry sand (± 0 MPs/kg) for the middle of the beach, of 255.9 MPs/kg of dry sand (± 33.3 MPs/kg) for the high water mark and of 255.9 MPs/kg of dry sand (± 33.3 MPs/kg) for the average (**Fig. 80b**). Finally an average increase of +100.6% of the concentrations of microplastics is observed from the low to the high season (**Fig. 80b**).

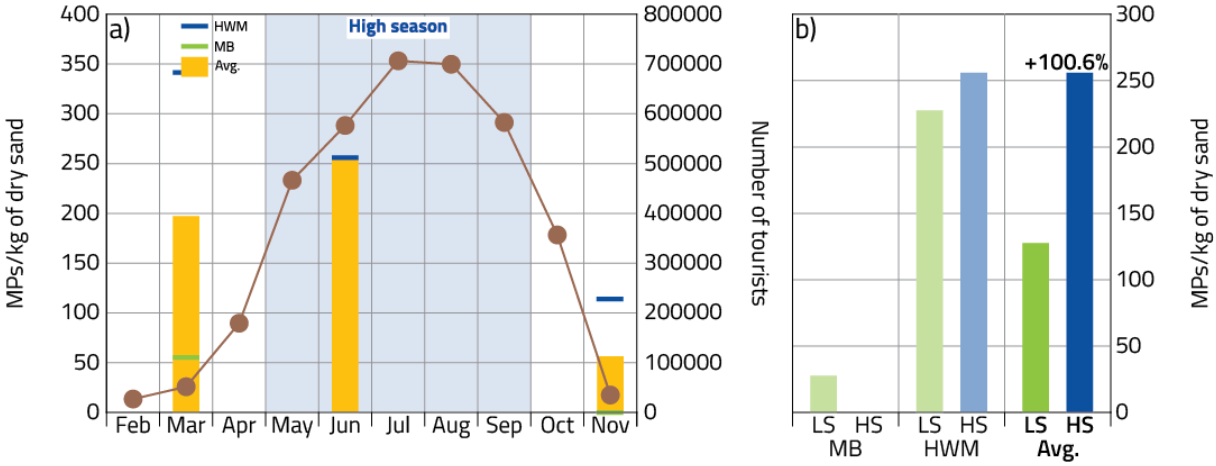

Figure 80: *average concentrations of microplastics for the beach of Tsoutsouras. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[18] in Crete. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Tsoutsouras are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=84.3% ±32.6%; LS=68.6% and HS=100%), followed by the aggregates (Avg=11.5% ±34.6%; LS=23.1% and HS=0%) and the fragments (Avg=4.2% ±12.5%; LS=8.3% and HS=0%). No films, foam and microbeads were found. During the high season only fibers were found in the sand (**Fig. 81**).

[18] Data source: monthly number of tourists welcomed on Crete in 2016.

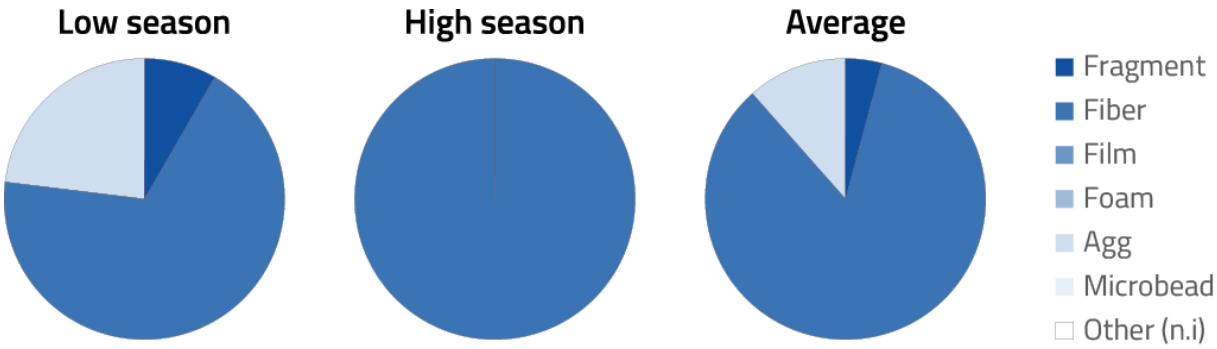

Figure 81: *comparison of the types of microplastics collected in the sand samples of the beach of Tsoutsouras. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Tsoutsouras are dominated by colored particles (Avg=63.6% ±20.1%; LS=49.4% and HS=77.8%), followed by the black particles (Avg=12.5% ±17.7%; LS=25% and HS=0%), the transparent particles (Avg=12.4% ±13.9%; LS=2.6% and HS=22.2%) and the white particles (Avg=11.5% ±16.3%; LS=23.1% and HS=0%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 82**).

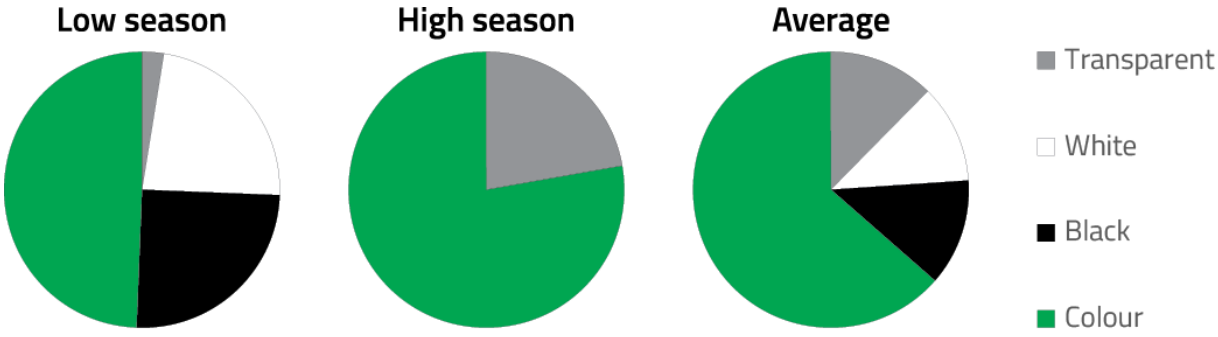

Figure 82: *comparison of the colors of microplastics collected in the sand samples of the beach of Tsoutsouras. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

4. Summary

The 12 campaigns of sand sampling conducted on 3 beaches of Crete in 2017 have revealed that the sand of all the monitored beaches is contaminated with microplastics:

- This is on the beach mainly used by locals that the concentrations of microplastics are the highest with an average of 447.8 MPs/kg of dry sand (± 498.3 MPs/kg), followed by the touristic beach with an average of 380.9 MPs/kg of dry sand (± 456.4 MPs/kg) and the remote beach with an average of 153.2 MPs/kg of dry sand (± 126.9 MPs/kg).
- This is during the high season that the concentrations are the highest with 536.6 MPs/kg of dry sand (± 593.7 MPs) for the touristic beach of Rethymo, 913 MPs/kg of dry sand (± 434.3 MPs/kg) for the beach of Arina and 255.9 MPs/kg of dry sand (± 0.4 MPs/kg) for the remote beach of Tsoutsouras. During the low season, these concentrations are respectively of 225.3 MPs/kg of dry sand (± 124.8 MPs/kg), 98.9 MPs/kg of dry sand (± 94.7 MPs/kg) and 127.6 MPs/kg of dry sand (± 129.7 MPs/kg).
- This is in the middle of the beach that the concentrations of microplastics are the highest for the touristic beach with an average of 578.2 MPs/kg of dry sand (± 565.4 MPs/kg), 448.1 MPs/kg of dry sand (± 399.4 MPs/kg) for the beach mainly used by locals and 27.7 MPs/kg of dry sand (± 27.7 MPs/kg) for the remote beach. At the high water mark, the concentrations of microplastics are respectively of 183.7 MPs/kg of dry sand (± 137.8 MPs/kg), 447.5 MPs/kg of dry sand (± 561.1 MPs/kg) and 236.9 MPs/kg of dry sand (± 93.8 MPs/kg).

- The microplastics found in the sand samples are largely dominated by the fibers, including synthetic and non-synthetic fibers, as they represent on average 81.2% (± 21.5%) of all the particles. The fragments represent the second most important category as they account for 17% (± 21.1%) of the particles.
- Finally, colored particles are the most abundant (66.6 ± 2.4%) followed by the black particles (14.7 ± 5.1%), the transparent particles (13.7 ± 7.3%) and the white particles (5 ± 4.8%).

VI. Mykonos

1. Touristic beach: Platis Gyalos

a) Characteristics of the beach

The touristic beach of Platis Gyalos is an urban beach, located in the municipality of Platis Gyalos in the south western side of Mykonos, facing the sea to the south. It has a total length of ±295m, a width of ±22m and is composed at 70% of sand and 30% of pebbles with a smooth slope. The monitored fixed portion of the beach has a surface of 1611 m^2. It has a pier situated on the western side. The beach is mainly used for recreational activities during the high season (swimming, sunbathing and local people) and the low season (local people). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach, has many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 37.4141N, 25.3428E (starting point) and 37.4142N, 25.3439E (ending point) (**Fig. 83**). Drink and food outlets are situated directly on the beach and the closest harbor is situated 8 km away to the west. The beach is cleaned once a day during the high season.

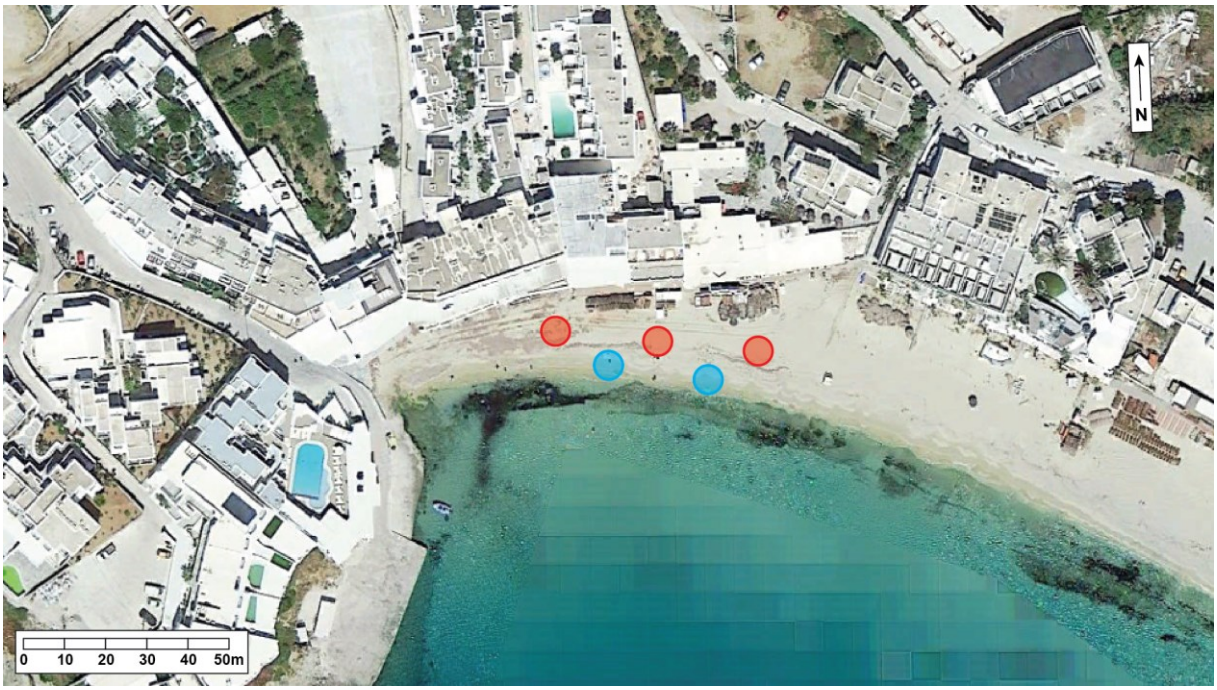

Figure 83: *location map of the sampling sites of the beach of Platis Gyalos. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The touristic beach of Platis Gyalos was sampled for microplastics in June and November of 2017 (**Fig. 84**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in November (199 MPs/kg of dry sand ± 25.9 MPs/kg), while the

highest averaged concentration is observed in June (1959 MPs/kg of dry sand ± 255.3 MPs/kg) (**Fig. 84a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in November (56.9 MPs/kg of dry sand ± 7.4 MPs/kg) and the highest in June (646.8 MPs/kg of dry sand ± 84.3 MPs/kg) (**Fig. 84a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in November (127.9 MPs/kg of dry sand ± 71.1 MPs/kg) and the highest in June (1302.9 MPs/kg of dry sand ± 656.1 MPs/kg) (**Fig. 84a**, yellow bars). With only 2 months available, it is difficult to discuss of the possible seasonal variations of the concentrations of microplastics. However, the concentrations are clearly higher in June than in November (**Fig. 84a**). During the low season the average concentrations is of 199 MPs/kg of dry sand (± 25.9 MPs/kg) for the middle of the beach, of 56.9 MPs/kg of dry sand (± 7.4 MPs/kg) for the high water mark and of 127.9 MPs/kg of dry sand (± 16.7 MPs/kg) for the average (**Fig. 84b**). During the high season the average concentrations is of 1959 MPs/kg of dry sand (± 255.3 MPs/kg) for the middle of the beach, of 646.8 MPs/kg of dry sand (± 84.3 MPs/kg) for the high water mark and of 1302.9 MPs/kg of dry sand (± 169.8 MPs/kg) for the average (**Fig. 84b**). The concentrations are always higher during the high season, no matter the origin of the sample. Finally an average increase of +918.3% of the concentrations of microplastics is observed from the low to the high season (**Fig. 84b**).

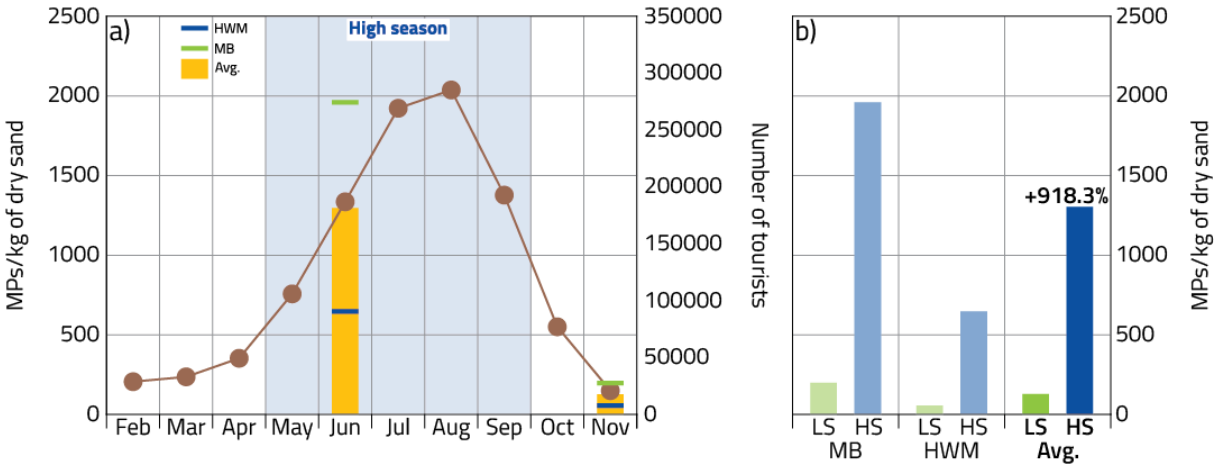

Figure 84: *average concentrations of microplastics for the beach of Platis Gyalos. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[19] in Mykonos. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Platis Gyalos are dominated by the fragments (Avg=53.4% ±10.9%; LS=46.4% and HS=60.4%), followed by the fibers, including both synthetic and non-synthetic fibers (Avg=24% ±16.3%; LS=13.4% and HS=34.6%), the films (Avg=11.5% ±17.8%; LS=18.8% and HS=4.3%), the foam (Avg=10.7% ±21.4%; LS=21.4% and HS=0%) and the particles not identified but suspected to be microplastics (Avg=0.4% ±0.7%; LS=0% and HS=0.7%). No

[19] Data source: monthly number of arrivals at Mykonos airport in 2017, https://www.jmk-airport.gr/uploads/sys_nodelng/2/2891/Mikonos_FY_Traffic_2017vs2016.pdf

aggregates and microbeads were found. The proportion of fibers and fragments is higher during the high season compared to the low season (**Fig. 85**).

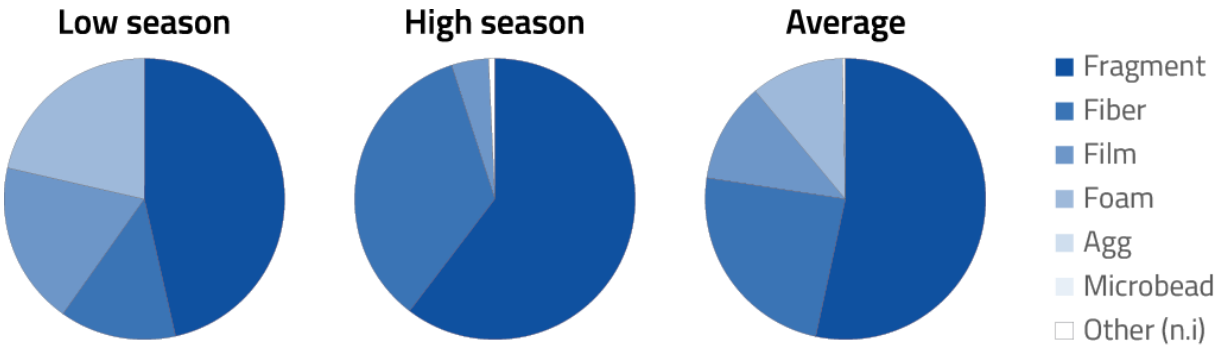

Figure 85: *comparison of the types of microplastics collected in the sand samples of the beach of Platis Gyalos. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Platis Gyalos are dominated by colored particles (Avg=85.7% ±10%; LS=78.6% and HS=92.8%), followed by the white particles (Avg=10.7% ±15.2%; LS=21.4% and HS=0%), the transparent particles (Avg=2.5% ±3.6%; LS=0% and HS=5.1%) and the black particles (Avg=1.1% ±1.5%; LS=0% and HS=2.2%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 86**).

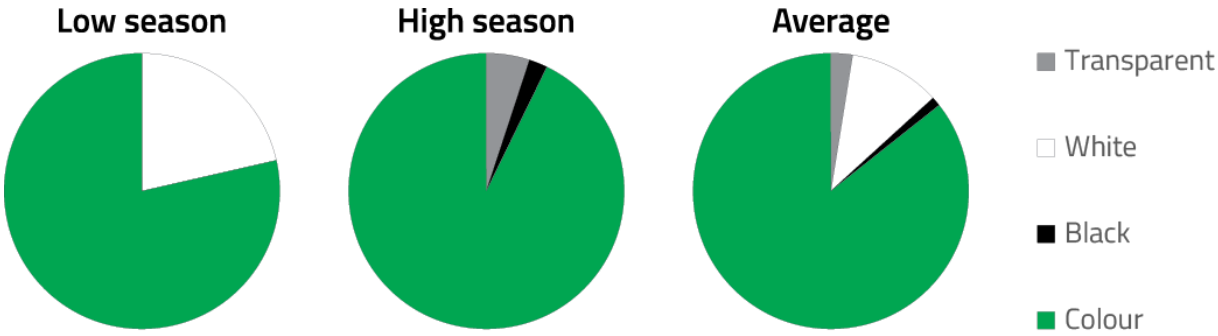

Figure 86: *comparison of the colors of microplastics collected in the sand samples of the beach of Platis Gyalos. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

2. Beach mainly used by locals: Fokos

a) Characteristics of the beach

The beach of Fokos was selected as it is a popular beach mainly used by locals. It is a semi-rural beach, located in the municipality of Fokos in the north eastern side of Mykonos, facing the sea to the NW. It has a total length of ±203m, a width of ±49m and is composed at 60% of sand and 40% of pebbles with a smooth slope. The monitored fixed portion of the beach has a surface of 3800 m^2. The beach is mainly used for recreational activities during the high season (swimming, sunbathing and local people) and the low season (local people). It is accessible by vehicles and for pedestrians. In the area situated directly behind the beach, very few services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 37.4815N, 25.4101E (starting point) and 37.4807N, 25.4103E (ending point) (**Fig. 87**). The closest harbor is situated 14 km away to the west. The beach is cleaned once every 2 weeks from April to October.

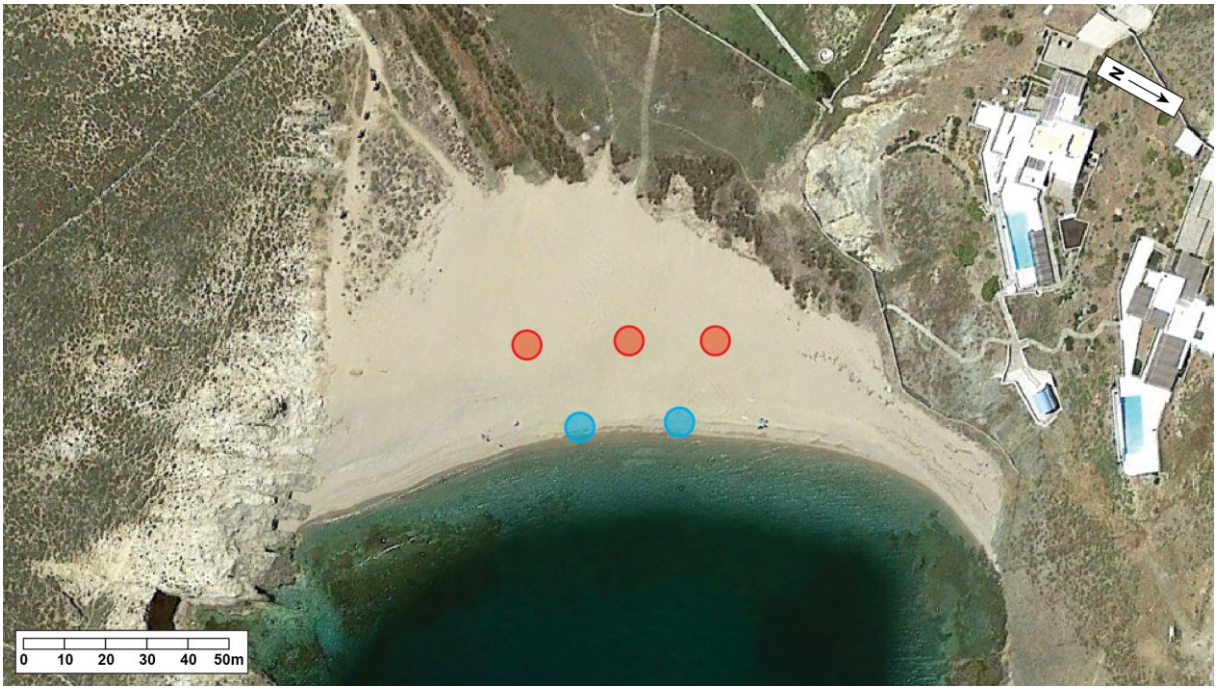

Figure 87: *location map of the sampling sites of the beach of Fokos. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The beach of Fokos, mainly used by locals, was sampled for microplastics in June and November of 2017 (**Fig. 88**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in November as no microplastics were found, while the highest averaged concentration is observed in June (139.8 MPs/kg of dry sand ± 18.2 MPs/kg) (**Fig. 88a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in June (56.4 MPs/kg of dry sand ± 7.4 MPs/kg) and the highest in November (454.9 MPs/kg of dry sand ± 59.3 MPs/kg) (**Fig. 88a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in June (98.1 MPs/kg of dry sand ± 41.7 MPs/kg) and the highest in November (227.5 MPs/kg of dry sand ± 227.5 MPs/kg) (**Fig. 88a**, yellow bars). With only 2 months available, it is difficult to discuss of the possible seasonal variations of the concentrations of microplastics. However, the concentrations are clearly higher in November than in June (**Fig. 88a**). During the low season no microplastics were found at the middle of the beach, average concentrations of 454.9 MPs/kg of dry sand (± 59.3 MPs/kg) were found at the high water mark and of 227.5 MPs/kg of dry sand (± 29.6 MPs/kg) for the average (**Fig. 88b**). During the high season the average concentrations is of 139.8 MPs/kg of dry sand (± 18.2 MPs/kg) for the middle of the beach, of 56.4 MPs/kg of dry sand (± 7.4 MPs/kg) for the high water mark and of 98.1 MPs/kg of dry sand (± 12.8 MPs/kg) for the average (**Fig. 88b**). The concentrations are higher during the high season for the samples from the middle of the beach and lower for the samples from the high water mark. Finally an average decrease of -56.9% of the concentrations of microplastics is observed from the low to the high season (**Fig. 88b**).

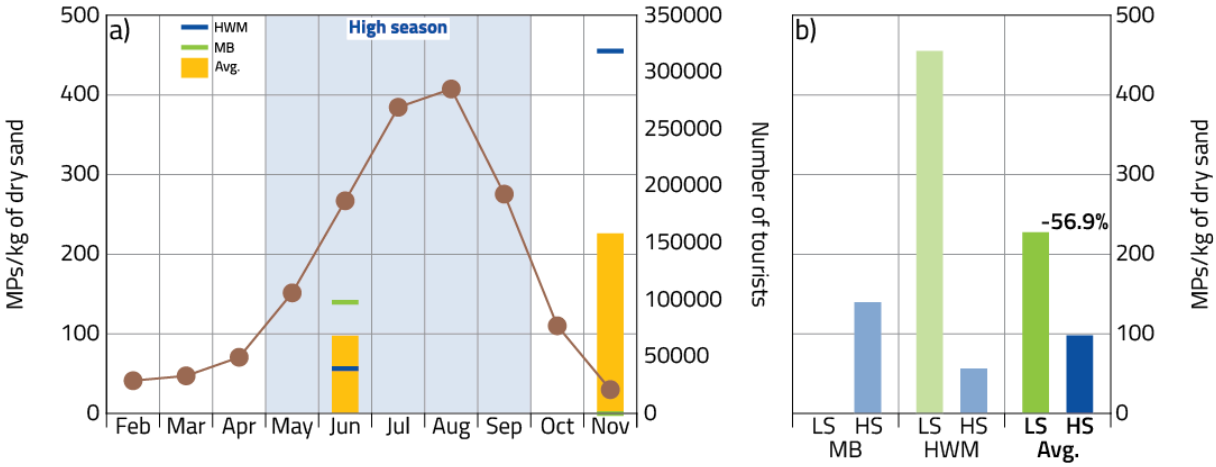

Figure 88: *average concentrations of microplastics for the beach of Fokos. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[20] in Mykonos. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Fokos are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=41.3% ±31.2%; LS=17.6% and HS=65%), followed by the fragments (Avg=25.6% ±20.6%; LS=41.2% and HS=10%), the foam (Avg=17.6% ±20.4%; LS=35.3% and HS=0%) and the films (Avg=15.4% ±27.3%; LS=5.9% and HS=25%). No aggregates and microbeads were found. The proportion of fibers is higher during the high season compared to the low season (**Fig. 89**).

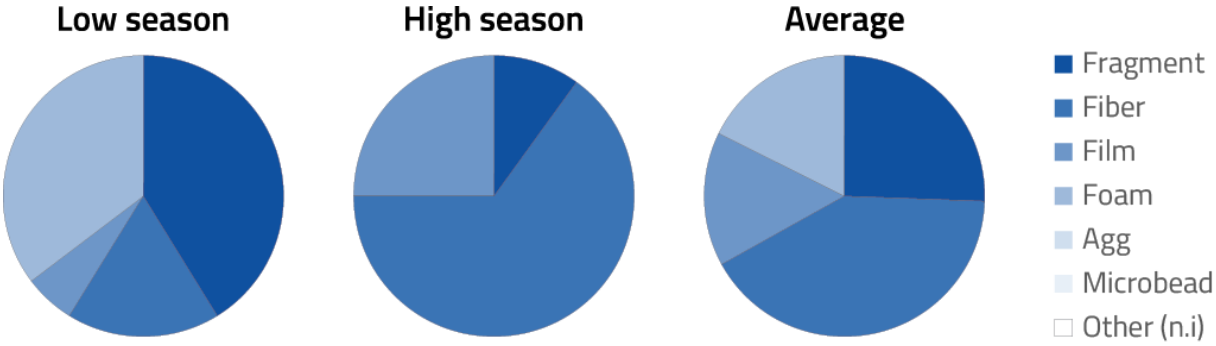

Figure 89: *comparison of the types of microplastics collected in the sand samples of the beach of Fokos. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Fokos are dominated by colored particles (Avg=47.4% ±24.5%; LS=64.7% and HS=30%), followed by the transparent particles (Avg=35% ±49.5%; LS=0% and HS=70%) and the white particles (Avg=17.6% ±25%; LS=35.3% and HS=0%). No black particles were found. The proportion of colored particles is lower during the high season compared to the low season (**Fig. 90**).

[20] Data source: monthly number of arrivals at Mykonos airport in 2017, https://www.jmk-airport.gr/uploads/sys_nodelng/2/2891/Mikonos_FY_Traffic_2017vs2016.pdf

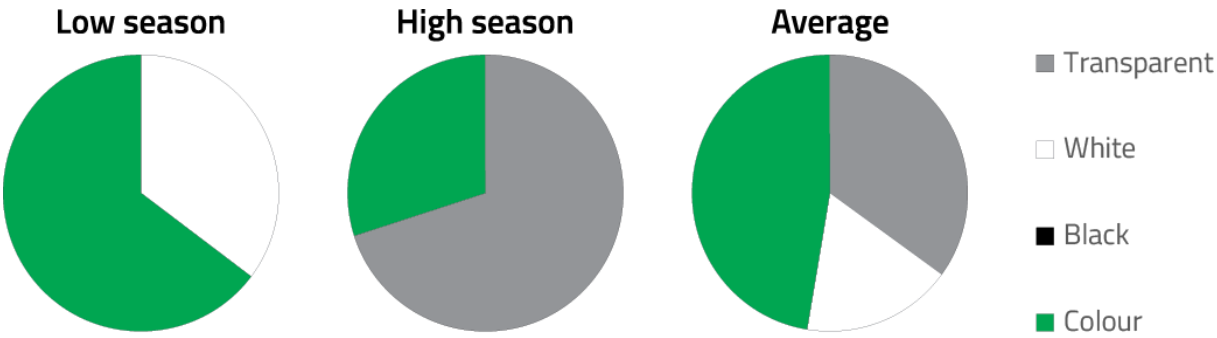

Figure 90: *comparison of the colors of microplastics collected in the sand samples of the beach of Fokos. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

3. Remote beach: Merchia

a) Characteristics of the beach

The remote beach of Merchia is a rural beach, located in the municipality of Merchia in the north eastern side of Mykonos, is facing the sea to the NW. It has a total length of ±132m, a width of ±35m and is composed at 70% of pebbles and 30% of sand with a smooth slope. The monitored fixed portion of the beach has a surface of 2147 m^2. The beach is mainly used for recreational activities during the high season (swimming and sunbathing). It is accessible by vehicles and for pedestrians. The area situated directly behind the beach is a semi-rural area with no services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 37.4719N, 25.4284E (starting point) and 37.4711N, 25.4289E (ending point) (**Fig. 91**). The closest harbor is situated 15 km away to the east. The beach is cleaned once a month during the high season.

Figure 91: *location map of the sampling sites of the beach of Merchia. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The remote beach of Merchia was sampled for microplastics in June and November of 2017 (**Fig. 92**). The lowest averaged concentration of microplastics extracted from the samples collected at the

middle of the beaches is observed in November (28.4 MPs/kg of dry sand ± 3.7 MPs/kg), while the highest averaged concentration is observed in June (224.3 MPs/kg of dry sand ± 29.2 MPs/kg) (**Fig. 92a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in November, as no microplastics were found and the highest in June (1606.2 MPs/kg of dry sand ± 209.3 MPs/kg) (**Fig. 92a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in November (14.2 MPs/kg of dry sand ± 14.2 MPs/kg) and the highest in June (915.3 MPs/kg of dry sand ± 690.9 MPs/kg) (**Fig. 92a**, yellow bars). With only 2 months available, it is difficult to discuss of the possible seasonal variations of the concentrations of microplastics. However, the concentrations are clearly higher in June than in November (**Fig. 92a**). During the low season the average concentrations is of 28.4 MPs/kg of dry sand (± 3.7 MPs/kg) for the middle of the beach, no microplastics for the high water mark and of 14.2 MPs/kg of dry sand (± 1.9 MPs/kg) for the average (Fig. 109b). During the high season the average concentrations is of 224.3 MPs/kg of dry sand (± 29.2 MPs/kg) for the middle of the beach, of 1606.2 MPs/kg of dry sand (± 209.3 MPs/kg) for the high water mark and of 915.3 MPs/kg of dry sand (± 119.3 MPs/kg) for the average (**Fig. 92b**). The concentrations are always higher during the high season, no matter the origin of the sample. Finally an average increase of +6338.1% of the concentrations of microplastics is observed from the low to the high season (**Fig. 92b**).

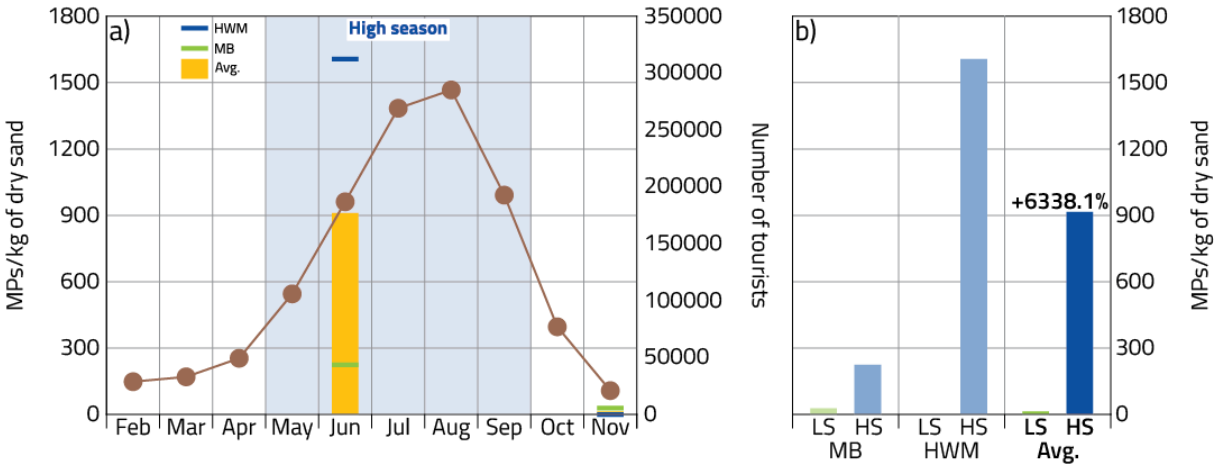

Figure 92: *average concentrations of microplastics for the beach of Merchia. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[21] in Mykonos. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Merchia are dominated by the fragments (Avg=54.4% ±52.7%; LS=100% and HS=8.9%), followed by the fibers, including both synthetic and non-synthetic fibers (Avg=41.6% ±48.7%; LS=0% and HS=83.1%), the particles not identified but suspected to be microplastics (Avg=3.1% ±7.2%; LS=0% and HS=6.3%) and the films

[21] Data source: monthly number of arrivals at Mykonos airport in 2017, https://www.jmk-airport.gr/uploads/sys_nodelng/2/2891/Mikonos_FY_Traffic_2017vs2016.pdf

(Avg=0.9% ±2%; LS=0% and HS=1.8%). No aggregates, foam and microbeads were found. Only fragments were found during the low season (**Fig. 93**).

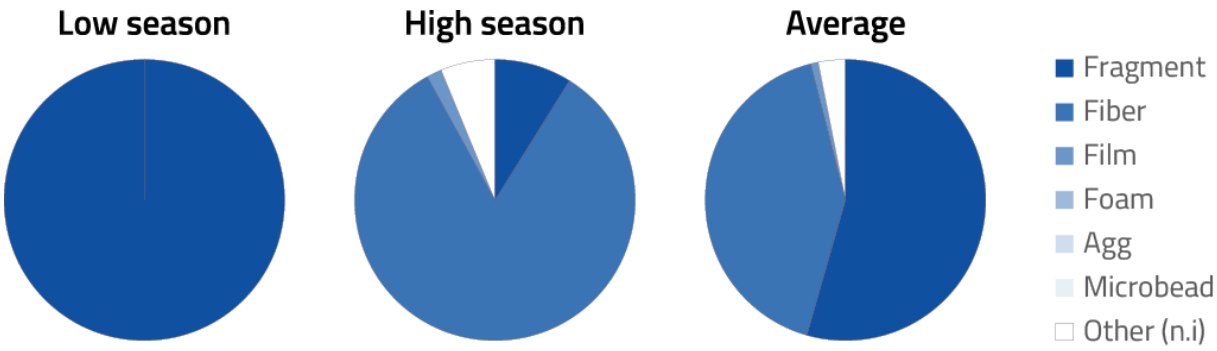

Figure 93: *comparison of the types of microplastics collected in the sand samples of the beach of Merchia. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Merchia are dominated by colored particles (Avg=72.1% ±39.5%; LS=100% and HS=44.2%), followed by the transparent particles (Avg=21.8% ±30.8%; LS=0% and HS=43.5%) and the black particles (Avg=6.1% ±8.7%; LS=0% and HS=12.3%). No white particles were found. The proportion of colored particles is lower during the high season compared to the low season (**Fig. 94**).

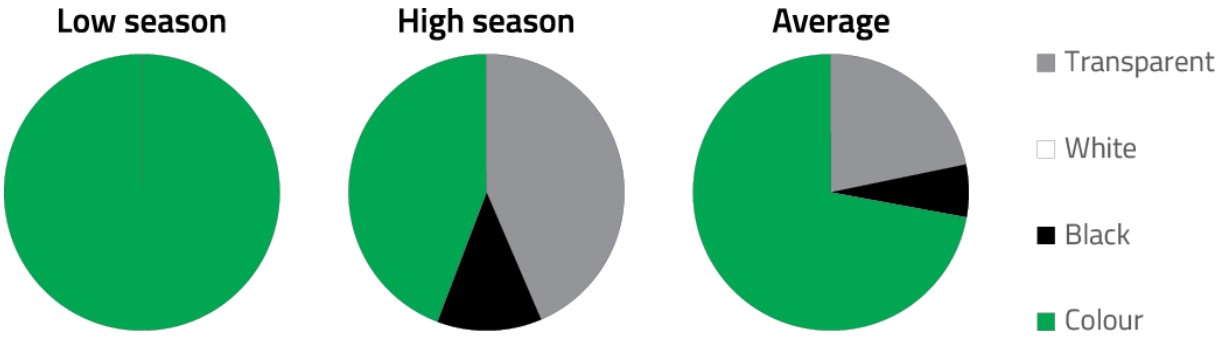

Figure 94: *comparison of the colors of microplastics collected in the sand samples of the beach of Merchia. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

4. Summary

The 6 campaigns of sand sampling conducted on 3 beaches of Mykonos in 2017 have revealed that the sand of all the monitored beaches is contaminated with microplastics:

- This is on the touristic beach that the concentrations of microplastics are the highest with an average of 715.4 MPs/kg of dry sand (± 750.2 MPs/kg), followed by the remote beach with an average of 464.7 MPs/kg of dry sand (± 664.7 MPs/kg) and the beach mainly used by locals with an average of 162.8 MPs/kg of dry sand (± 175.8 MPs/kg).
- This is during the high season that the concentrations are the highest with 1302.9 MPs/kg of dry sand (± 656.1 MPs) for the touristic beach of Platis gyalos, 98.1 MPs/kg of dry sand (± 41.7 MPs/kg) for the beach of Fokos and 915.3 MPs/kg of dry sand (± 690.9 MPs/kg) for the remote beach of Merchia. During the low season, these concentrations are respectively of 127.9 MPs/kg of dry sand (± 71.1 MPs/kg), 227.5 MPs/kg of dry sand (± 227.5 MPs/kg) and 14.2 MPs/kg of dry sand (± 14.2 MPs/kg).

- This is in the middle of the beach that the concentrations of microplastics are the highest for the touristic beach with an average of 1079 MPs/kg of dry sand (± 880 MPs/kg). This is at the water mark the concentrations of microplastics are the highest for the beach mainly used by locals with 255.7 MPs/kg of dry sand (± 199.3 MPs/kg) and for the remote beach with 803.1 MPs/kg of dry sand (± 803.1 MPs/kg).
- The microplastics found in the sand samples are largely dominated by the fibers, including synthetic and non-synthetic fibers, as they represent on average 60.9% (± 23.6%) of all the particles. The fragments represent the second most important category as they account for 26.4% (± 25.2%) of the particles.
- Finally, colored particles are the most abundant (68.4 ± 15.9%) followed by the transparent particles (19.8 ± 13.3%), the white particles (9.5 ± 7.3%) and the black particles (2.4 ± 2.7%).

VII. Rhodes

1. Touristic beach: Tsampika

a) Characteristics of the beach

The touristic beach of Tsampika is a semi-urban beach, located in the municipality of Archangelos in the central western side of Rhodes, facing the sea to the SW. It has a total length of ±1200m, a width of ±30m and is composed at 95% of sand and 5% of pebbles with a smooth slope of 1%. The monitored fixed portion of the beach has a surface of 2813 m^2. The beach is mainly used for recreational activities during the high season (swimming and sunbathing). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach, has many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 36.2276N, 27.1478E (starting point) and 36.2283N, 27.1483E (ending point) (**Fig. 95**). Drink and food outlets are situated directly on the beach and the closest harbor is situated 28 km away to the north. The beach is cleaned annually by the local authorities.

Figure 95: *location of map the sampling sites of the beach of Tsampika. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The touristic beach of Tsampika was sampled for microplastics in February, June, August and November of 2017 (**Fig. 96**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in February (128.1 MPs/kg of dry sand ± 16.7 MPs/kg), while the highest averaged concentration is observed in November (2044.4 MPs/kg of dry sand ± 266.4 MPs/kg) (**Fig. 96a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in February (142.9 MPs/kg of dry sand ± 18.6 MPs/kg) and the highest in November (4873.4 MPs/kg of dry sand ± 635 MPs/kg) (**Fig. 96a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in February (135.5 MPs/kg of dry sand ± 7.4 MPs/kg) and the highest in November (3458.9 MPs/kg of dry sand ± 1414.5 MPs/kg) (**Fig. 96a**, yellow bars). The variations of concentrations of microplastics do not show any seasonal pattern, probably due to the very high concentrations observed in November (**Fig. 96a**). During the low season the average concentrations is of 1086.2 MPs/kg of dry sand (± 958.1 MPs/kg) for the middle of the beach, of 2508.2 MPs/kg of dry sand (± 2365.3 MPs/kg) for the high water mark and of 1797.2 MPs/kg of dry sand (± 1661.7 MPs/kg) for the average **(Fig. 96b**). During the high season the average concentrations is of 612 MPs/kg of dry sand (± 396.4 MPs/kg) for the middle of the beach, of 1272.8 MPs/kg of dry sand (± 220.8 MPs/kg) for the high water mark and of 942.4 MPs/kg of dry sand (± 87.8 MPs/kg) for the average (**Fig. 96b**). The concentrations are always lower during the high season, no matter the origin of the sample. Finally an average decrease of -47.6% of the concentrations of microplastics is observed from the low to the high season (**Fig. 96b**).

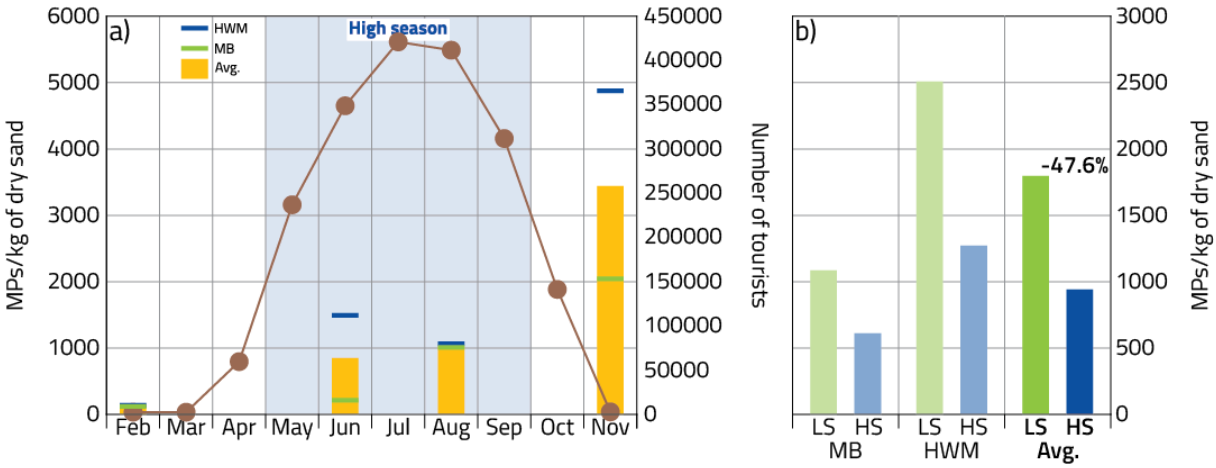

Figure 96: *average concentrations of microplastics for the beach of Tsampika. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[22] in Rhodes. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Tsampika are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=64% ±28.5%; LS=74% and HS=54%),

[22] Data source: International tourists arrivals at main greeks airports – Rhodes – for 2014.

followed by the fragments (Avg=32.1% ±26.5%; LS=23.2% and HS=41.1%), the films (Avg=2.7% ±4.2%; LS=1.5% and HS=3.8%), the foam (Avg=0.7% ±1.4%; LS=1% and HS=0.4%) and the aggregates (Avg=0.5% ±1%; LS=0.3% and HS=0.7%). No microbeads were found. The proportion of fibers and fragments is higher during the high season compared to the low season (**Fig. 97**).

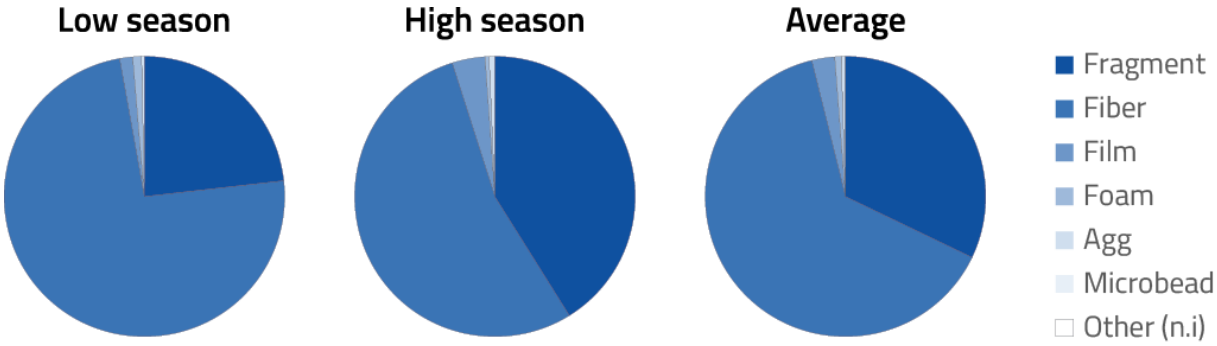

Figure 97: *comparison of the types of microplastics collected in the sand samples of the beach of Tsampika. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Tsampika are dominated by colored particles (Avg=70.7% ±14.9%; LS=60.2% and HS=81.2%), followed by the transparent particles (Avg=18.7% ±14.6%; LS=29% and HS=8.4%), the black particles (Avg=8.2% ±1.7%; LS=9.4% and HS=7%) and the white particles (Avg=2.4% ±1.4%; LS=1.5% and HS=3.4%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 98**).

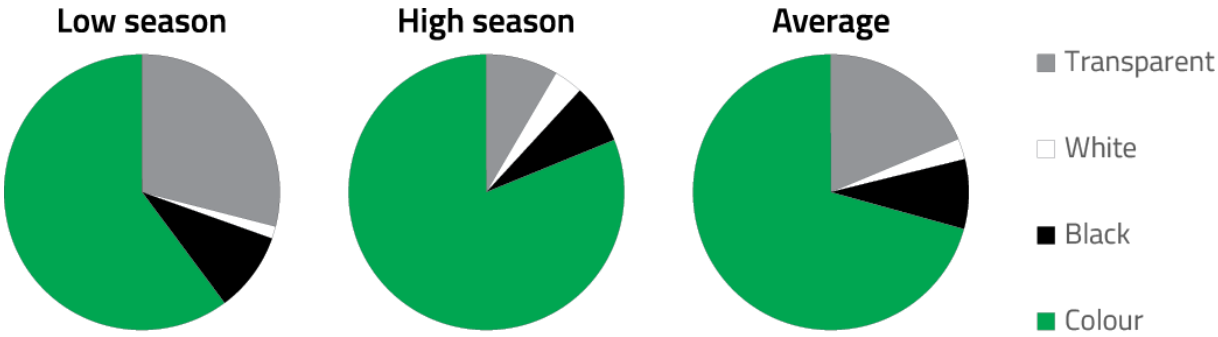

Figure 98: *comparison of the colors of microplastics collected in the sand samples of the beach of Tsampika. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

2. Beach mainly used by locals: Afandou

a) Characteristics of the beach

The beach of Afandou was selected as it is a popular beach mainly used by locals. It is a semi-rural beach, located in the municipality of Afandou in the central western side of Rhodes, facing the sea to the SW. It has a total length of ±6200m, a width of ±15m and is composed at 60% of pebbles and 40% of sand with a smooth slope of 2%. The monitored fixed portion of the beach has a surface of 2049 m^2. The beach is mainly used for recreational activities during the high season (swimming, sunbathing and local people) and the low season (local people, fishing). It is accessible by vehicles/boats and for pedestrians. In the area situated directly behind the beach, no services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 36.2728N, 28.1700E (starting point) and 36.2736N, 28.1705E (ending point) (**Fig. 99**). Drink and food

outlets are situated directly on the beach and the closest harbor is situated 2 km away to the east. The beach is cleaned annually by the local authorities.

Figure 99: *location of map the sampling sites of the beach of Afandou. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The beach of Afandou, mainly used by locals, was sampled for microplastics in February, June and August of 2017 (**Fig. 100**). The samples from November were broken when they arrived at the laboratory. They were discarded for possible contamination. The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in June (56.9 MPs/kg of dry sand ± 7.4 MPs/kg), while the highest averaged concentration is observed in August (597.1 MPs/kg of dry sand ± 77.8 MPs/kg) (**Fig. 100a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in June (28.4 MPs/kg of dry sand ± 3.7 MPs/kg) and the highest in February (284.3 MPs/kg of dry sand ± 37 MPs/kg) (**Fig. 100a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in June (42.6 MPs/kg of dry sand ± 14.2 MPs/kg) and the highest in August (355.4 MPs/kg of dry sand ± 241.7 MPs/kg) (**Fig. 100a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Rhodes: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 100a**). During the low season the average concentrations is of 85.3 MPs/kg of dry sand (± 11.1 MPs/kg) for the middle of the beach, of 284.3 MPs/kg of dry sand (± 37 MPs/kg) for the high water mark and of 184.8 MPs/kg of dry sand (± 24.1 MPs/kg) for the average (**Fig. 100b**). During the high season the average concentrations is of 327 MPs/kg of dry sand (± 270.1 MPs/kg) for the middle of the beach, of 71.1 MPs/kg of dry sand (± 42.6 MPs/kg) for the high water mark and of 199 MPs/kg of dry sand (± 156.4 MPs/kg) for the average (**Fig. 100b**). The concentrations are higher during the high season for the samples from the middle of the beach and lower for the samples from the high water mark. Finally

an average increase of +7.7% of the concentrations of microplastics is observed from the low to the high season (**Fig. 100b**).

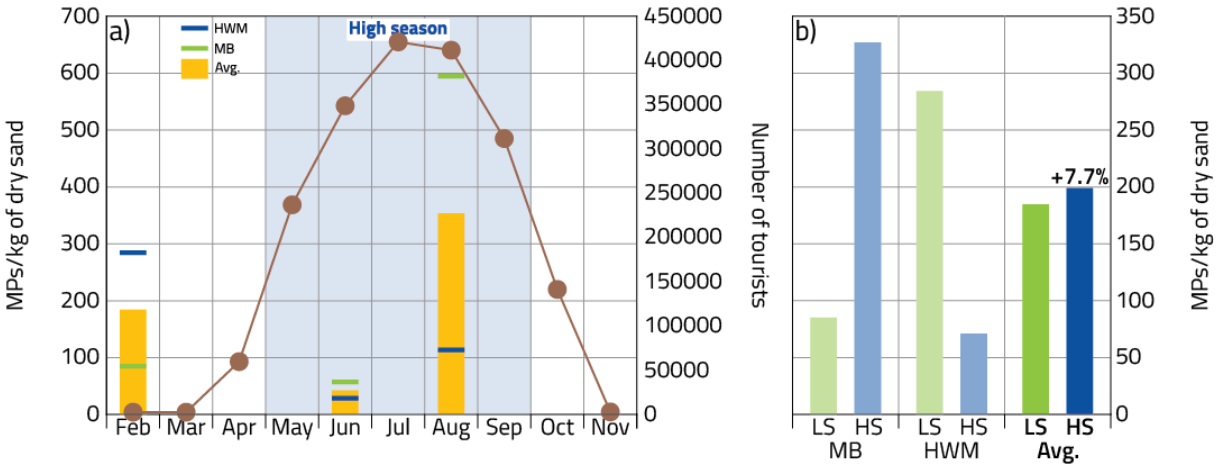

Figure 100: *average concentrations of microplastics for the beach of Afandou. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[23] in Rhodes. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Afandou are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=73.1% ±30.5%; LS=66.7% and HS=79.5%), followed by the fragments (Avg=18% ±22.1%; LS=16.7% and HS=19.3%) and the films (Avg=8.9% ±13.4%; LS=16.7% and HS=1.2%). No aggregates, foam and microbeads were found. The proportion of fibers and fragments is higher during the high season compared to the low season (**Fig. 101**).

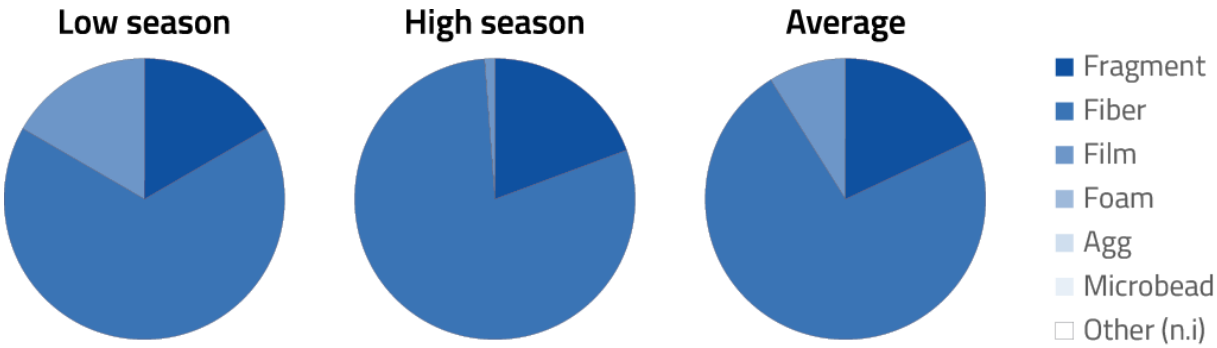

Figure 101: *comparison of the types of microplastics collected in the sand samples of the beach of Afandou. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Afandou are dominated by colored particles (Avg=52.4% ±1.3%; LS=53.3% and HS=51.5%), followed by the transparent particles (Avg=24.3% ±1.1%; LS=25% and HS=23.5%) and the black particles (Avg=23.3% ±2.4%; LS=21.7% and HS=25%). No white particles were found. The proportion of colored particles is lower during the high season compared to the low season (**Fig. 102**).

[23] Data source: International tourists arrivals at main greeks airports – Rhodes – for 2014.

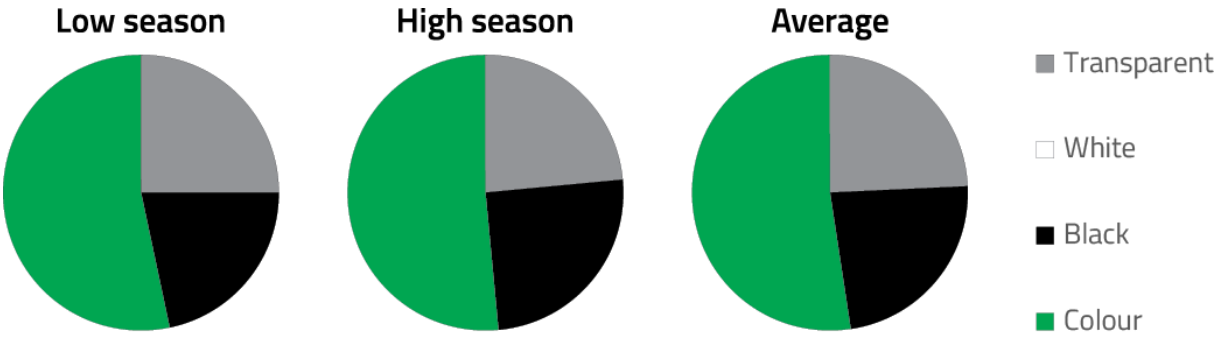

Figure 102: *comparison of the colors of microplastics collected in the sand samples of the beach of Afandou. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

3. Remote beach: Gennadi

a) Characteristics of the beach

The remote beach of Gennadi is a semi-rural beach, located in the municipality of Gennadi in the south eastern side of Rhodes, facing the sea to the SW. It has a total length of ±10km, a width of ±40m and is composed at 60% of sand and 40% of pebbles with a smooth slope of 2%. The monitored fixed portion of the beach has a surface of 3998 m^2. The beach is mainly used for recreational activities during the high season (swimming and sunbathing) and the low season (fishing). It is accessible by vehicles/boats and for pedestrians. The area situated directly behind the beach is a semi-rural area with very limited services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 36.0252N, 27.9334E (starting point) and 36.0259N, 27.9339E (ending point) (**Fig. 103**). Drink and food outlets are situated directly on the beach and the closest harbor is situated 2 km away to the east. The beach is cleaned annually by the local authorities.

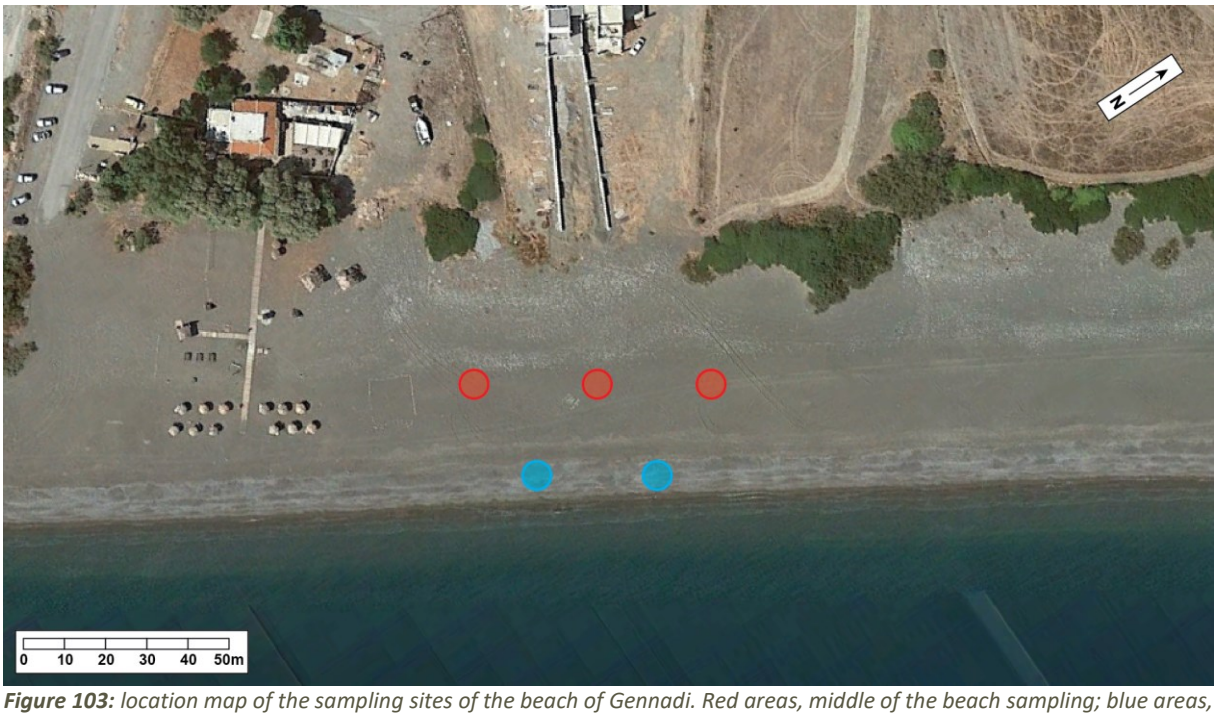

Figure 103: *location map of the sampling sites of the beach of Gennadi. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The remote beach of Gennadi was sampled for microplastics in February, June, August and November of 2017 (**Fig. 104**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in November (85.3 MPs/kg of dry sand ± 11.1 MPs/kg), while the highest averaged concentration is observed in June (255.9 MPs/kg of dry sand ± 33.3 MPs/kg) (**Fig. 104a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in August (56.9 MPs/kg of dry sand ± 7.4 MPs/kg) and the highest in November (255.9 MPs/kg of dry sand ± 33.3 MPs/kg) (**Fig. 104a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in August (56.9 MPs/kg of dry sand ± 0.4 MPs/kg) and the highest in February (199 MPs/kg of dry sand ± 56.9 MPs/kg) (**Fig. 104a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to be the opposite of the average number of tourists welcomed to Rhodes: lower concentrations are observed during the touristic season and higher concentrations are observed during the low season (**Fig. 104a**). During the low season the average concentrations is of 170.6 MPs/kg of dry sand (± 85.3 MPs/kg) for the middle of the beach, of 199 MPs/kg of dry sand (± 56.9 MPs/kg) for the high water mark and of 184.8 MPs/kg of dry sand (± 14.2 MPs/kg) for the average (**Fig. 104b**). During the high season the average concentrations is of 142.2 MPs/kg of dry sand (± 18.5 MPs/kg) for the middle of the beach, of 71.1 MPs/kg of dry sand (± 14.2 MPs/kg) for the high water mark and of 85.3 MPs/kg of dry sand (± 28.4 MPs/kg) for the average (**Fig. 104b**). The concentrations are always lower during the high season, no matter the origin of the sample. Finally an average decrease of -53.8% of the concentrations of microplastics is observed from the low to the high season (**Fig. 104b**).

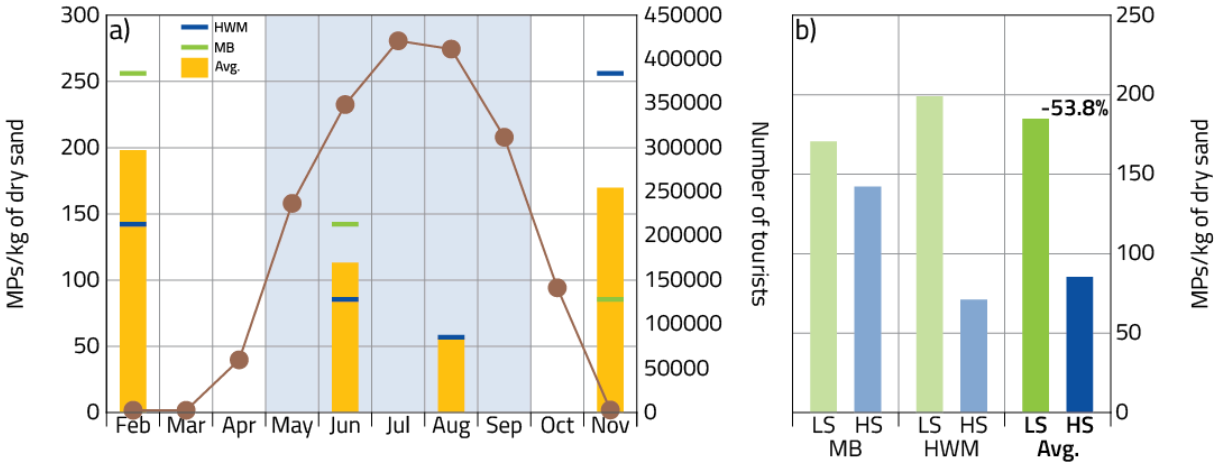

Figure 104: *average concentrations of microplastics for the beach of Gennadi. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[24] in Rhodes. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach Gennadi are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=68.6% ±16%; LS=78.3% and HS=58.9%),

[24] Data source: International tourists arrivals at main greeks airports – Rhodes – for 2014.

followed by the fragments (Avg=28.9% ±19.5%; LS=16.7% and HS=41.1%) and the films (Avg=2.5% ±7.6%; LS=5% and HS=0%). No aggregates, foam and microbeads were found. The proportion fragments is higher during the high season compared to the low season (**Fig. 105**).

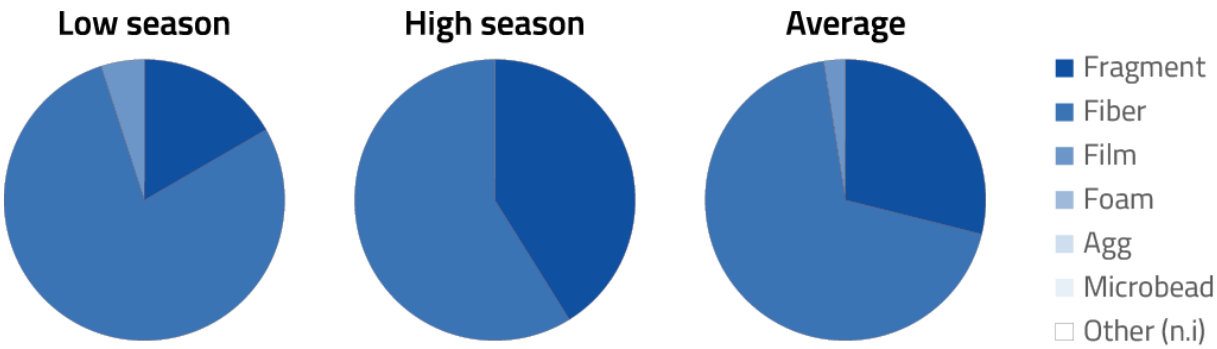

Figure 105: *comparison of the types of microplastics collected in the sand samples of the beach of Gennadi. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Gennadi are dominated by colored particles (Avg=65.8% ±2%; LS=67.2% and HS=64.4%), followed by the black particles (Avg=19.2% ±11.4%; LS=27.2% and HS=11.1%), the transparent particles (Avg=13.6% ±15.3%; LS=2.8% and HS=24.4%) and the white particles (Avg=1.4% ±2%; LS=2.8% and HS=0%). The proportion of colored particles is lower during the high season compared to the low season (**Fig. 106**).

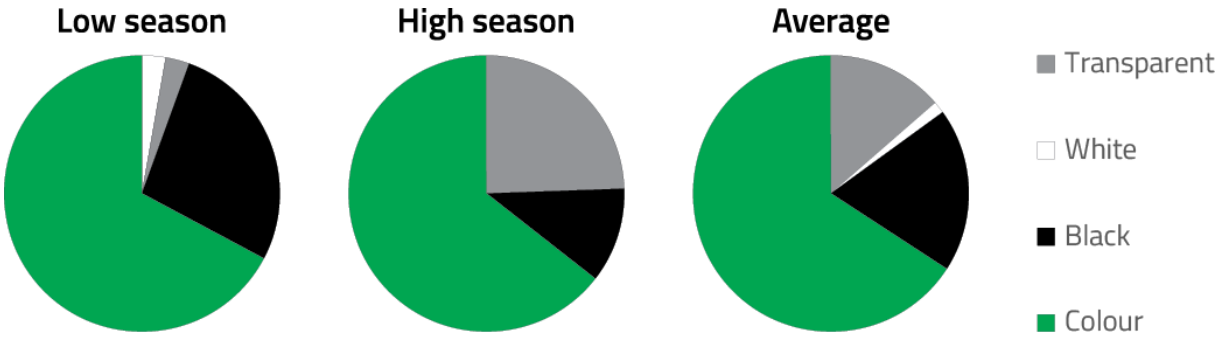

Figure 106: *comparison of the colors of microplastics collected in the sand samples of the beach of Gennadi. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

4. Summary

The 11 campaigns of sand sampling conducted on 3 beaches of Rhodes in 2017 have revealed that the sand of all the monitored beaches is contaminated with microplastics:

- This is on the touristic beach that the concentrations of microplastics are the highest with an average of 1369.8 MPs/kg of dry sand (± 1473 MPs/kg), followed by the beach mainly used by locals with an average of 194.3 MPs/kg of dry sand (± 198 MPs/kg) and the remote beach with an average of 146.2 MPs/kg of dry sand (± 75.1 MPs/kg).
- This is during the high season that the concentrations are the lowest with 942.4 MPs/kg of dry sand (± 460.6 MPs) for the touristic beach of Tsambika, 199 MPs/kg of dry sand (± 231.9 MPs/kg) for the beach of Afandou and 94.8 MPs/kg of dry sand (± 35.5 MPs/kg) for the remote beach of Gennadi. During the low season, these concentrations are respectively of 1797.2 MPs/kg of dry sand (± 1939.5 MPs/kg), 184.8 MPs/kg of dry sand (± 99.5 MPs/kg) and 184.8 MPs/kg of dry sand (± 73.9 MPs/kg).

- This is in the middle of the beach that the concentrations of microplastics are the lowest with an average of 849.1 MPs/kg of dry sand (± 770.6 MPs/kg) for the touristic beach, 246.4 MPs/kg of dry sand (± 248.2 MPs/kg) for the beach mainly used by locals and 161.1 MPs/kg of dry sand (± 70.9 MPs/kg) for the remote beach. At the high water mark, the concentrations of microplastics are respectively of 1890.5 MPs/kg of dry sand (± 1789.7 MPs/kg), 142.2 MPs/kg of dry sand (± 106.4 MPs/kg) and 135.1 MPs/kg of dry sand (± 76.2 MPs/kg).
- The microplastics found in the sand samples are largely dominated by the fibers, including synthetic and non-synthetic fibers, as they represent on average 64.6% (± 22.2%) of all the particles. The fragments represent the second most important category as they account for 33.2% (± 20.6%) of the particles.
- Finally, colored particles are the most abundant (63 ± 7.7%) followed by the transparent particles (18.9 ± 4.3%), the black particles (16.9 ± 6.4%) and the white particles (1.3 ± 1%).

VIII. Cyprus

1. Touristic beach: Sunrise

a) Characteristics of the beach

The touristic beach of Sunrise is an urban beach, located in the municipality of Protaras in the south western side of Cyprus, facing the sea to the NE. It has a total length of ±170m, a width of ±20m and is composed at 95% of sand and 5% of pebbles with a slope of 5%. The monitored fixed portion of the beach has a surface of 2157 m^2. The beach is mainly used for recreational activities during the high season (swimming, sunbathing and local people). It is only accessible for pedestrians. The area situated directly behind the beach, has many services and facilities provided to the beach users. The coordinates of the fixed 100m portion selected for the monitoring are: 35.0159N, 34.0546E (starting point) and 35.0167N, 34.0540E (ending point) (**Fig. 107**). The closest harbor is situated 3 km away to the north. The beach is cleaned 2 to 3 times per day during the high season.

Figure 107: *location map of the sampling sites of the beach of Sunrise. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The touristic beach of Sunrise was sampled for microplastics in February, June, August and November of 2017 (**Fig. 108**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in February (369.6 MPs/kg of dry sand ± 48.2 MPs/kg), while the highest averaged concentration is observed in June (3212.9 MPs/kg of dry sand ± 418.6 MPs/kg) (**Fig. 108a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in June (966.7 MPs/kg of dry sand ± 126 MPs/kg) and the highest in August (3355.1 MPs/kg of dry sand ± 437.2 MPs/kg) (**Fig. 108a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in February (369.6 MPs/kg of dry sand ± 48.2 MPs/kg) and the highest in August (3170.3 MPs/kg of dry sand ± 184.8 MPs/kg) (**Fig. 108a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Cyprus: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 108a**). During the low season the average concentrations is of 1066.2 MPs/kg of dry sand (± 696.6 MPs/kg) for the middle of the beach, of 3070.8 MPs/kg of dry sand (± 400.1 MPs/kg) for the high water mark and of 1393.2 MPs/kg of dry sand (± 1023.6 MPs/kg) for the average (**Fig. 108b**). During the high season the average concentrations is of 3099.2 MPs/kg of dry sand (± 113.7 MPs/kg) for the middle of the beach, of 2160.9 MPs/kg of dry sand (± 1194.2 MPs/kg) for the high water mark and of 2630 MPs/kg of dry sand (± 540.2 MPs/kg) for the average (**Fig. 108b**). The concentrations are higher during the high season for the samples from the middle of the beach and lower for the samples from the high water mark. Finally an average increase of +88.8% of the concentrations of microplastics is observed from the low to the high season (**Fig. 108b**).

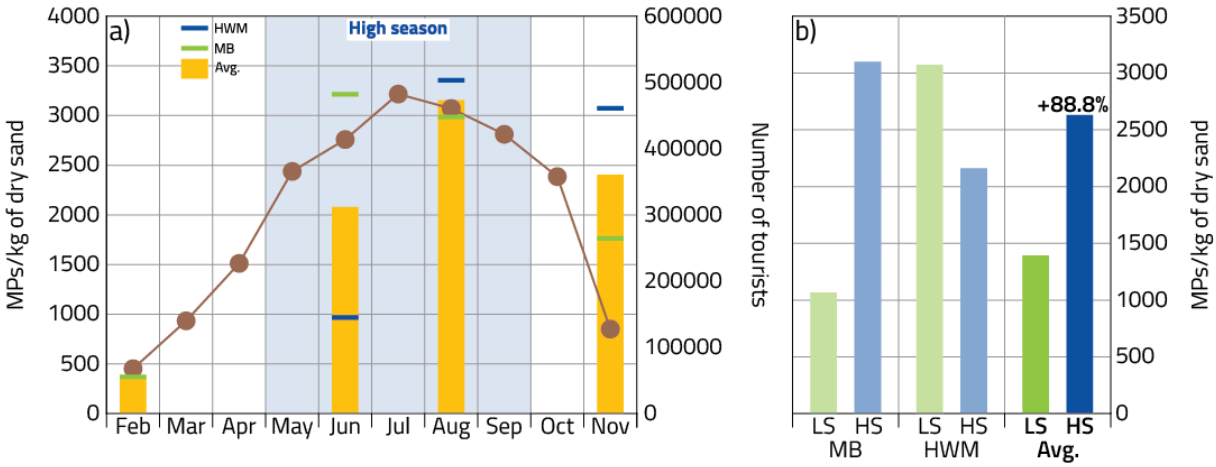

Figure 108: *average concentrations of microplastics for the beach of Sunrise. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists[25] in Cyprus. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

[25] Data source: arrivals of tourists by country of usual residence and month in 2016, http://www.cystat.gov.cy/mof/cystat/statistics.nsf/services_71main_en/services_71main_en?OpenForm&sub=1&sel=2#

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Sunrise are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=65.8% ±23.7%; LS=79.8% and HS=51.9%), followed by the fragments (Avg=30.3% ±25.2%; LS=18.5% and HS=42.2%), the films (Avg=2.2% ±2%; LS=1.7% and HS=2.7%), the foam (Avg=1.2% ±3.1%; LS=0% and HS=2.3%) and the aggregates (Avg=0.5% ±1.1%; LS=0% and HS=0.9%). No microbeads were found. The proportion of fragments is higher during the high season compared to the low season (**Fig. 109**).

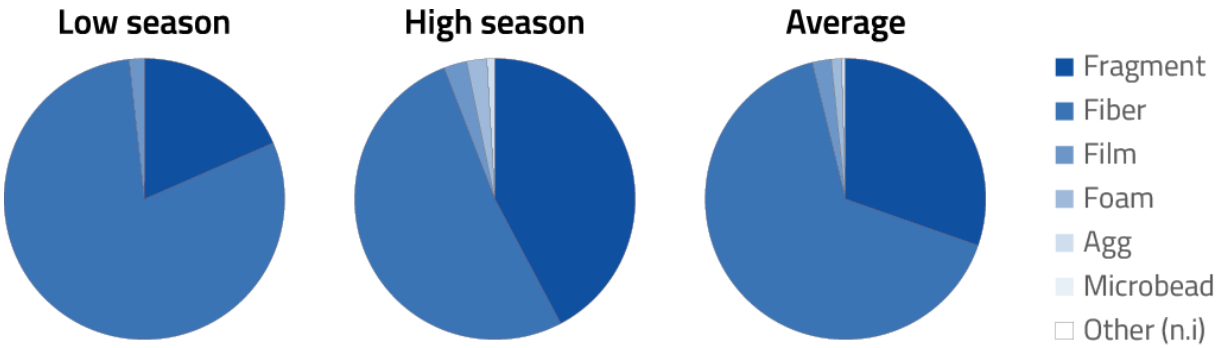

Figure 109: *comparison of the types of microplastics collected in the sand samples of the beach of Sunrise. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Sunrise are dominated by colored particles (Avg=66.9% ±7.1%; LS=61.9% and HS=71.9%), followed by the transparent particles (Avg=17.4% ±2.9%; LS=15.3% and HS=19.5%), the black particles (Avg=12.7% ±9.4%; LS=19.3% and HS=6.1%) and the white particles (Avg=3% ±0.6%; LS=3.4% and HS=2.5%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 110**).

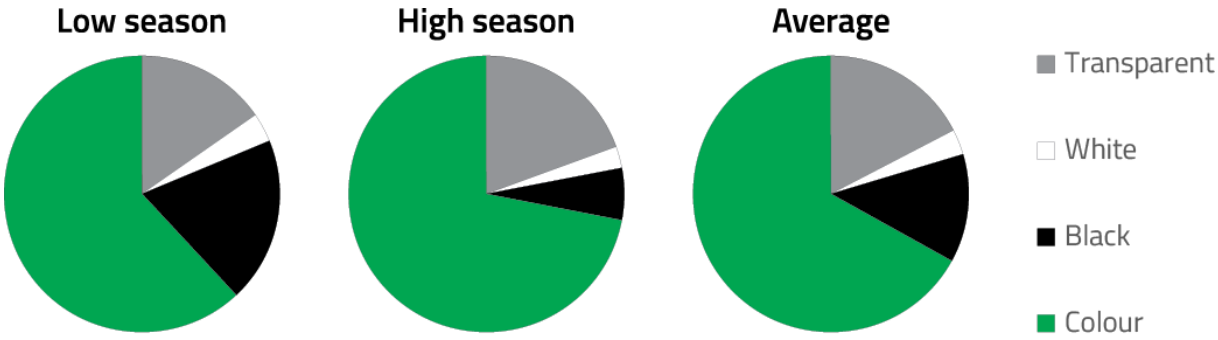

Figure 110: *comparison of the colors of microplastics collected in the sand samples of the beach of Sunrise. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

2. Beach mainly used by locals: Faros

a) Characteristics of the beach

The beach of Faros was selected as it is a popular beach mainly used by locals. It is a semi-urban beach, located in the municipality of Perivolia in the south eastern side of Cyprus, facing the sea to the east. It has a total length of ±310m, a width of ±60m and is composed at 80% of sand and 20% of pebbles with a slope of 15%. The monitored fixed portion of the beach has a surface of 4316 m^2. The beach is mainly used for recreational activities during the high season (swimming, sunbathing and local people) and the low season (local people). It is only accessible for pedestrians. In the area situated directly

behind the beach, few services and facilities provided to the beach users are found. The coordinates of the fixed 100m portion selected for the monitoring are: 34.8201N, 33.6049E (starting point) and 34.8210N, 33.6049E (ending point) (**Fig. 111**). Drink and food outlets are situated directly on the beach and the closest harbor is situated 12 km away to the north. The beach is cleaned daily during the high season.

Figure 111: *location map of the sampling sites of the beach of Faros. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The beach of Faros, mainly used by locals, was sampled for microplastics in February, June, August and November of 2017 (**Fig. 112**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in February (170.6 MPs/kg of dry sand ± 22.2 MPs/kg), while the highest averaged concentration is observed in June (682.4 MPs/kg of dry sand ± 88.9 MPs/kg) (**Fig. 112a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in June (113.7 MPs/kg of dry sand ± 14.8 MPs/kg) and the highest in August (341.2 MPs/kg of dry sand ± 44.5 MPs/kg) (**Fig. 112a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in February (170.6 MPs/kg of dry sand ± 22.2 MPs/kg) and the highest in August (440.7 MPs/kg of dry sand ± 99.5 MPs/kg) (**Fig. 112a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Cyprus: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 112a**). During the low season the average concentrations is of 312.8 MPs/kg of dry sand (± 142.2 MPs/kg) for the middle of the beach, of 312.8 MPs/kg of dry sand (± 40.8 MPs/kg) for the high water mark and of 277.2 MPs/kg of dry sand (± 106.6 MPs/kg) for the average (**Fig. 112b**). During the high season the average concentrations is of 611.3 MPs/kg of dry sand (± 71.1 MPs/kg) for the middle of the beach, of 227.5 MPs/kg of dry sand (± 113.7 MPs/kg) for the high water mark and of 419.4 MPs/kg of dry sand (± 21.3 MPs/kg) for the average (**Fig. 112b**). The concentrations are higher during the high season for the samples from the middle of the

beach and lower for the samples from the high water mark. Finally an average increase of +51.3% of the concentrations of microplastics is observed from the low to the high season (**Fig. 109b**).

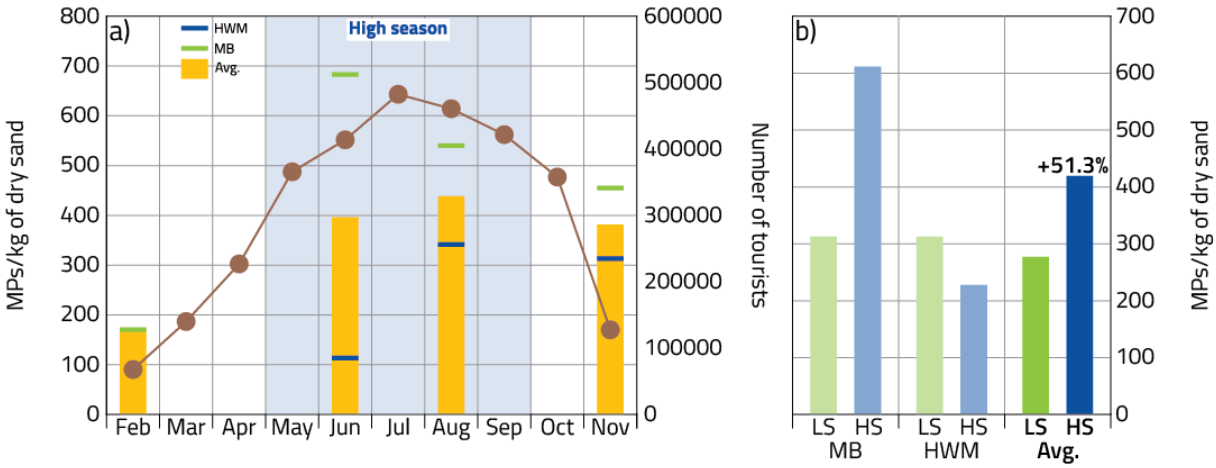

Figure 112: *average concentrations of microplastics for the beach of Faros. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists*[26] *in CYprus. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season*

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Faros are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=49.5% ±32.4%; LS=66.9% and HS=32%), followed by the fragments (Avg=46.9% ±36.4%; LS=33.1% and HS=60.7%) and the films (Avg=3.6% ±9.3%; LS=0% and HS=7.3%). No aggregates, foam and microbeads were found. The proportion of fragments is higher during the high season compared to the low season (**Fig. 113**).

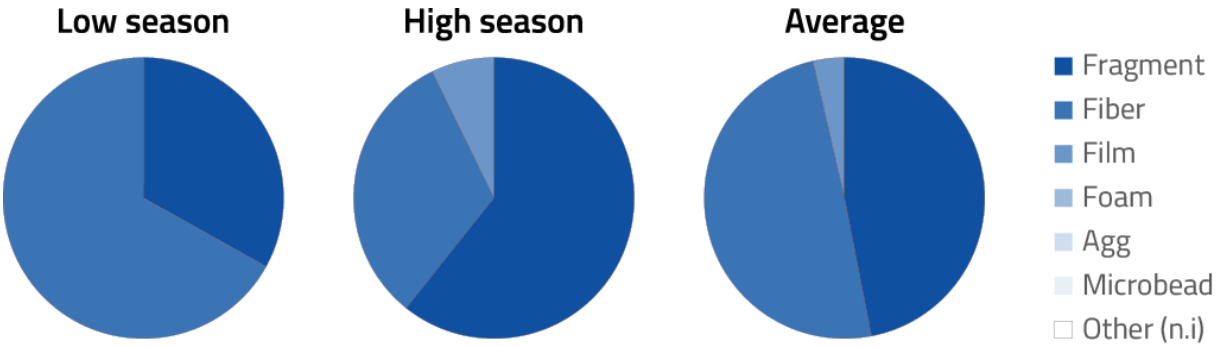

Figure 113: *comparison of the types of microplastics collected in the sand samples of the beach of Faros. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Faros are dominated by colored particles (Avg=73.3% ±18.9%; LS=60% and HS=86.6%), followed by the black particles (Avg=17.1% ±10.5%; LS=24.5% and HS=9.8%), the transparent particles (Avg=8.9% ±9.3%; LS=15.5% and HS=2.3%)

[26] Data source: arrivals of tourists by country of usual residence and month in 2016, http://www.cystat.gov.cy/mof/cystat/statistics.nsf/services_71main_en/services_71main_en?OpenForm&sub=1&sel=2#

and the white particles (Avg=0.7% ±0.9%; LS=0% and HS=1.3%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 114**).

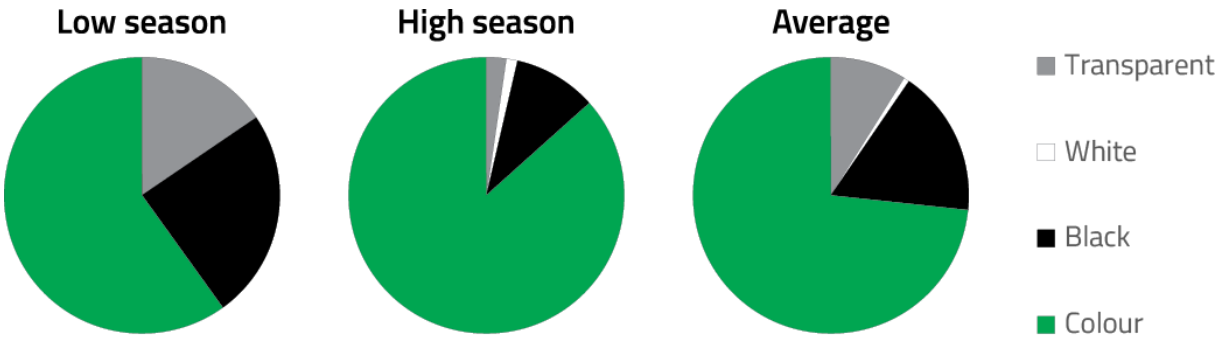

Figure 114: *comparison of the colors of microplastics collected in the sand samples of the beach of Faros. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

3. Remote beach: Timi

a) Characteristics of the beach

The remote beach of Timi is a semi-rural beach, located in the municipality of Timi in the south western side of Cyprus, facing the sea to the SW. It has a total length of ±120m, a width of ±30m and is composed at 50% of sand, 30% of pebbles and 20% of rocks with a slope of 20%. The monitored fixed portion of the beach has a surface of 2300 m^2. The beach is mainly used for recreational activities during the high season (swimming, sunbathing, local people and fishing). It is accessible by vehicles. The area situated directly behind beach is a semi-rural area with no services and facilities provided to the beach users. The beach is located behind the international airport of Paphos. The coordinates of the fixed 100m portion selected for the monitoring are: 34.7099N, 32.4879E (starting point) and 34.7091N, 32.4883E (ending point) (**Fig. 115**). The closest harbor is situated 13 km away to the NW. The beach is cleaned 2 to 3 times per year.

Figure 115: *location map of the sampling sites of the beach of Timi. Red areas, middle of the beach sampling; blue areas, high water mark sampling.*

b) Seasonality of the microplastics

The remote beach of Timi was sampled for microplastics in February, June, August and November of 2017 (**Fig. 116**). The lowest averaged concentration of microplastics extracted from the samples collected at the middle of the beaches is observed in November (28.4 MPs/kg of dry sand ± 3.7 MPs/kg), while the highest averaged concentration is observed in June (853 MPs/kg of dry sand ± 111.1 MPs/kg) (**Fig. 116a**, green strokes). When the samples collected at the high water mark are considered, the lowest averaged concentration is observed in November (56.9 MPs/kg of dry sand ± 7.4 MPs/kg) and the highest in June (1791.3 MPs/kg of dry sand ± 233.4 MPs/kg) (**Fig. 116a**, blue strokes). Finally, when the concentrations from the middle of the beach and from the high water mark are averaged together, the lowest concentration is found in November (42.6 MPs/kg of dry sand ± 14.2 MPs/kg) and the highest in June (1322.1 MPs/kg of dry sand ± 469.1 MPs/kg) (**Fig. 116a**, yellow bars). The seasonal variations of the concentrations of microplastics seems to follow the average number of tourists welcomed to Cyprus: higher concentrations are observed during the touristic season and lower concentrations are observed during the low season (**Fig. 116a**). During the low season the average concentrations is of 71.1 MPs/kg of dry sand (± 42.6 MPs/kg) for the middle of the beach, of 56.9 MPs/kg of dry sand (± 7.4 MPs/kg) for the high water mark and of 64 MPs/kg of dry sand (± 21.3 MPs/kg) for the average (**Fig. 116b**). During the high season the average concentrations is of 526 MPs/kg of dry sand (± 327 MPs/kg) for the middle of the beach, of 995.2 MPs/kg of dry sand (± 796.1 MPs/kg) for the high water mark and of 760.6 MPs/kg of dry sand (± 561.6 MPs/kg) for the average (**Fig. 116b**). The concentrations are always higher during the high season, no matter the origin of the sample. Finally an average increase of +1088.9% of the concentrations of microplastics is observed from the low to the high season (**Fig. 116b**).

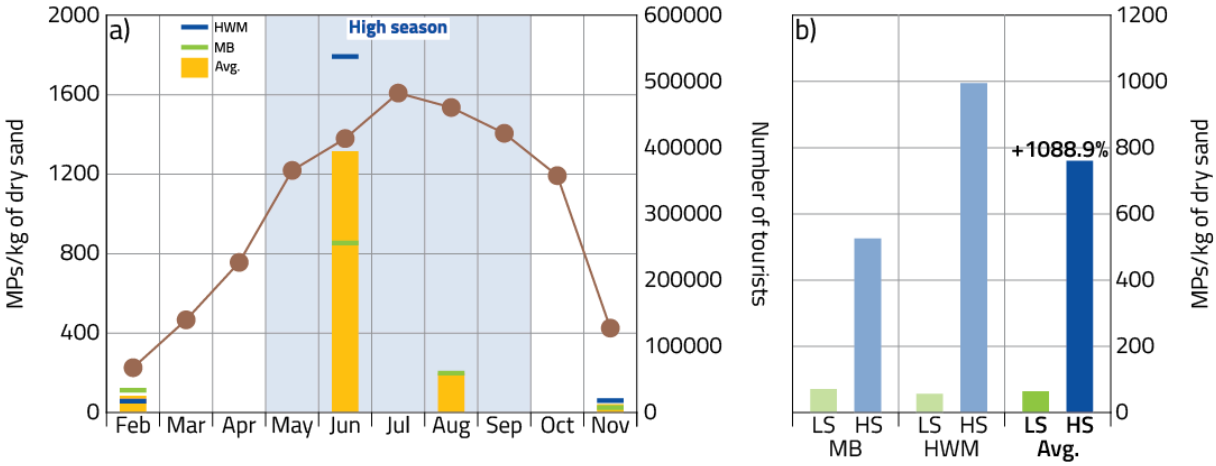

Figure 116: *average concentrations of microplastics for the beach of Timi. a) Average concentrations of the microplastics in the sand collected each month on the fixed 100m portions of beach. Yellow bars, average concentrations (Avg.); blue line, average concentrations for the samples collected at the high water mark (HWM); green line, average concentrations for the samples collected in the middle of the beach (MB); and brown line and dots (right axis), average monthly number of tourists*[27] *in Cyprus. b) Comparison of the concentrations of microplastics during the low season (LS, green bars) and the high season (HS, blue bars) for the samples collected in the middle of the beach (MB), at the high water mark (HWM) and the average for all the samples (Avg.). The percentage reported refers to the increase with respect to the low season.*

[27] Data source: arrivals of tourists by country of usual residence and month in 2016, http://www.cystat.gov.cy/mof/cystat/statistics.nsf/services_71main_en/services_71main_en?OpenForm&sub=1&sel=2#

c) Types of microplastics

On average the microplastics extracted from the sand of the beach of Timi are dominated by the fibers, including both synthetic and non-synthetic fibers (Avg=61.7% ±38.7%; LS=93.8% and HS=29.7%), followed by the fragments (Avg=36.5% ±38.8%; LS=6.3% and HS=66.7%) and the foam (Avg=1.8% ±5.1%; LS=0% and HS=3.6%). No films, aggregates and microbeads were found. The proportion of fragments is higher during the high season compared to the low season (**Fig. 117**).

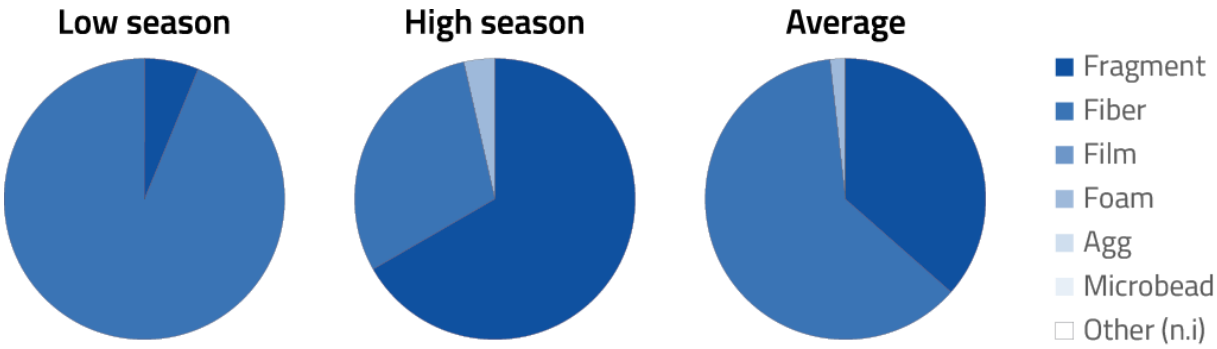

Figure 117: *comparison of the types of microplastics collected in the sand samples of the beach of Timi. The 3 pie charts show the distribution of the different types for the low season, the high season and the average.*

d) Colors of microplastics

On average the microplastics extracted from the sand of the beach of Timi are dominated by colored particles (Avg=57.2% ±27.9%; LS=37.5% and HS=77%), followed by the black particles (Avg=28.1% ±39.8%; LS=56.3% and HS=0%), the white particles (Avg=9.3% ±13.2%; LS=0% and HS=18.7%) and the transparent particles (Avg=5.3% ±1.3%; LS=6.3% and HS=4.4%). The proportion of colored particles is higher during the high season compared to the low season (**Fig. 118**).

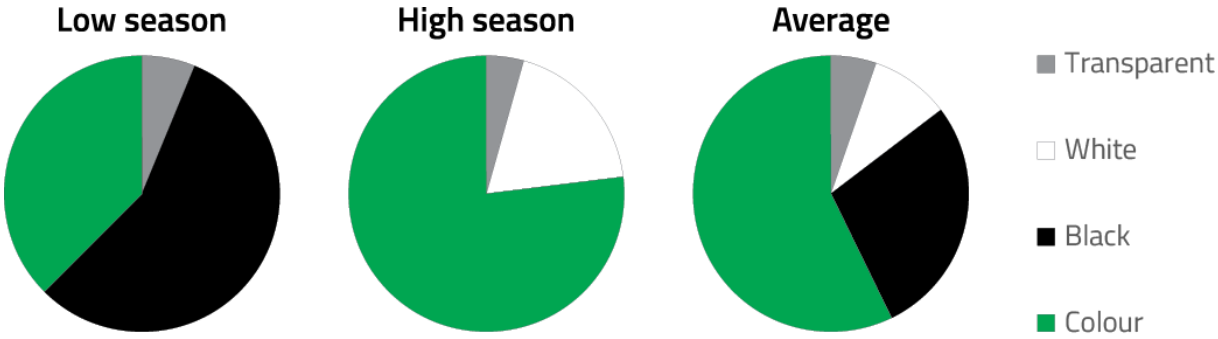

Figure 118: *comparison of the colors of microplastics collected in the sand samples of the beach of Timi. The 3 pie charts show the distribution of the different categories of color for the low season, the high season and the average.*

4. Summary

The 12 campaigns of sand sampling conducted on 3 beaches of Cyprus in 2017 have revealed that the sand of all the monitored beaches is contaminated with microplastics:

- This is on the touristic beach that the concentrations of microplastics are the highest with an average of 2246.2 MPs/kg of dry sand (± 1120.1 MPs/kg), followed by the remote beach with an average of 412.3 MPs/kg of dry sand (± 578.4 MPs/kg) and the beach mainly used by locals with an average of 373.7 MPs/kg of dry sand (± 186.4 MPs/kg).

- This is during the high season that the concentrations are the highest with 2630 MPs/kg of dry sand (± 969.3 MPs) for the touristic beach of Sun Rise, 419.4 MPs/kg of dry sand (± 214.1 MPs/kg) for the beach of Faros and 760.6 MPs/kg of dry sand (± 652.2 MPs/kg) for the remote beach of Timi. During the low season, these concentrations are respectively of 1734.4 MPs/kg of dry sand (± 1102.9 MPs/kg), 312.8 MPs/kg of dry sand (± 116.1 MPs/kg) and 64 MPs/kg of dry sand (± 31 MPs/kg).
- This is in the middle of the beach that the concentrations of microplastics are the highest with an average of 2082.7 MPs/kg of dry sand (± 1132.4 MPs/kg) for the touristic beach, 462 MPs/kg of dry sand (± 186.9 MPs/kg) for the beach mainly used by locals and 298.5 MPs/kg of dry sand (± 325.7 MPs/kg) for the remote beach. At the high water mark, the concentrations of microplastics are respectively of 2464.2 MPs/kg of dry sand (± 1065.2 MPs/kg), 255.9 MPs/kg of dry sand (± 101.2 MPs/kg) and 526 MPs/kg of dry sand (± 732.8 MPs/kg).
- The microplastics found in the sand samples are largely dominated by the fragments as they represent on average 56.5% (± 30.7%) of all the particles. The fibers, including synthetic and non-synthetic fibers, represent the second most important category as they account for 37.9% (± 24%) of the particles.
- Finally, colored particles are the most abundant (65.8 ± 6.6%) followed by the black particles (19.3 ± 6.5%), the transparent particles (10.5 ± 5.1%) and the white particles (4.3 ± 3.7%).

Part F: SURFACE WATER SAMPLES FROM SICILY AND CYPRUS

In parallel to the marine litter surveys and the sand sampling performed on the selected beaches of Sicily and Cyprus, surface water sampling were conducted in 2018. In this section, preliminary results for the 6 beaches monitored are shown. As the last samples were received at the end of November and due to the huge amount of particles present in the samples, only the results for the 0.5 – 5mm fraction (see *Part B.I.2.a*) are presented here. The results on the smaller fraction (<0.5mm), will be added once the analysis done.

I. Sicily

1. Touristic beach: Giardini Naxos

a) Sampling

Figure 119: *location map of the surface water sampling off the beach of Giardini Naxos.*

Two surface water sampling were conducted off the touristic beach of Giardini Naxos in June and August 2018 along the same transect (**Fig. 119**). Due to the configuration of the beach, the sampling were realized perpendicular to the fixed 100m portion selected for the marine litter surveys and the sand sampling. A net for microplastic sampling, with a mesh size of 100µm and an opening of 0.7x0.4m, was deployed along the 2093m of the transects. The net sampled a surface of 1465.1 m^2 for each transect. Following the procedure, the particles caught by the net were transferred into clean glass jars and immersed in ethanol. The samples were shipped to Barcelona, Spain, for the microplastics analysis.

b) Results

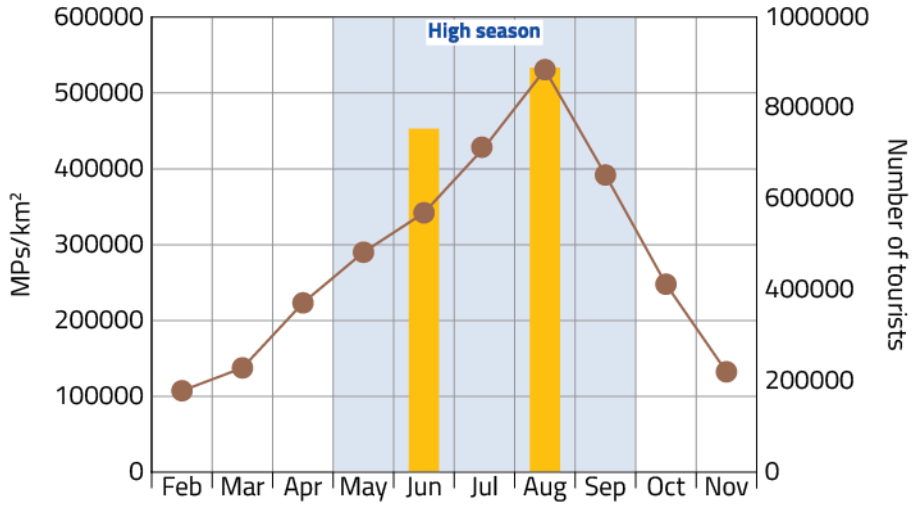

Figure 120: *concentrations of microplastics in the surface waters off the beach of Giardini Naxos. Here only the particles of the 0.5 – 5.0mm are considered.*

The two surface water sampling off the beach of Giardini Naxos show similar concentrations of microplastics ranging from 0.5 to 5.0mm (**Fig. 120**). As no samples were collected during the low season, it is impossible to discuss a possible seasonal variation. The average concentration is of 493481.7 MPs/km^2 (± 40270.3 MPs/km^2). As only the 0.5 – 5.0mm fraction has been analyzed. This concentration should be seen as the minimum concentration of microplastics in the surface waters off the beach of Giardini Naxos.

2. Beach mainly used by locals: Letojani

a) Sampling

Figure 121: *location map of the surface water sampling off the beach of Letojani.*

Two surface water sampling were conducted off the beach mainly used by locals of Letojani in June and August 2018 along the same transect (**Fig. 121**). The sampling were realized parallel to the fixed 100m portion selected for the marine litter surveys and the sand sampling. A net for microplastic sampling, with a mesh size of 100µm and an opening of 0.7x0.4m, was deployed along the 3035m of

the transects. The net sampled a surface of 2124.5 m^2 for each transect. Following the procedure, the particles caught by the net were transferred into clean glass jars and immersed in ethanol. The samples were shipped to Barcelona, Spain, for the microplastics analysis.

b) Results

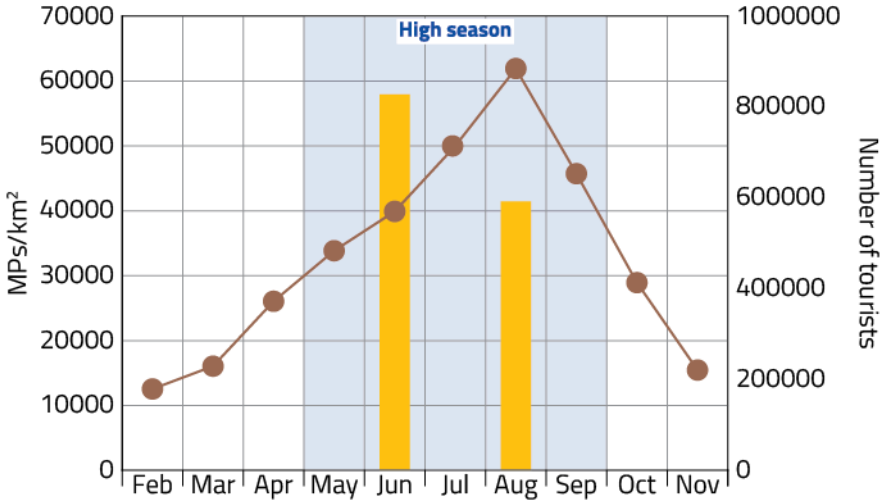

Figure 122: *concentrations of microplastics in the surface waters off the beach of Letojani. Here only the particles of the 0.5 – 5.0mm are considered.*

The two surface water sampling off the beach of Giardini Naxos show similar concentrations of microplastics ranging from 0.5 to 5.0mm (**Fig. 122**). As no samples were collected during the low season, it is impossible to discuss a possible seasonal variation. The average concentration is of 49659.7 MPs/km^2 (± 8237.2 MPs/km^2). This concentration should be seen as the minimum concentration of microplastics in the surface waters off the beach of Letojani.

3. Remote beach: Fondaco Parrino

a) Sampling

Figure 123: *location map of the surface water sampling off the beach of Fondaco Parrino.*

Two surface water sampling were conducted off the remote beach of Fondaco Parrino in June and August 2018 along the same transect (**Fig. 123**). The sampling were realized parallel to the fixed 100m portion selected for the marine litter surveys and the sand sampling. A net for microplastic sampling, with a mesh size of 100µm and an opening of 0.7x0.4m, was deployed along the 2062m of the transects. The net sampled a surface of 1443.4m^2 for each transect. Following the procedure, the particles caught by the net were transferred into clean glass jars and immersed in ethanol. The samples were shipped to Barcelona, Spain, for the microplastics analysis.

b) Results

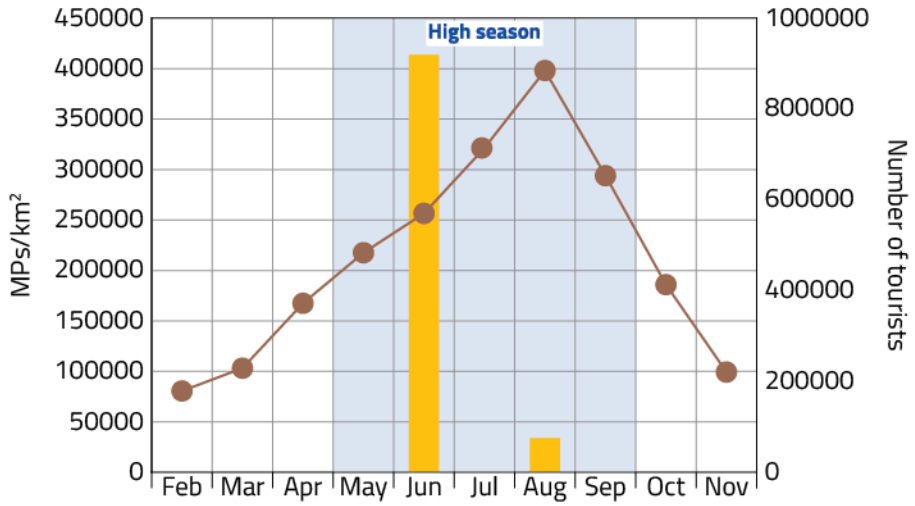

Figure 124: *concentrations of microplastics in the surface waters off the beach of Fondaco Parrino. Here only the particles of the 0.5 – 5.0mm are considered.*

The two surface water sampling off the beach of Giardini Naxos show very different concentrations of microplastics ranging from 0.5 to 5.0mm (**Fig. 124**). As no samples were collected during the low season, it is impossible to discuss a possible seasonal variation. The average concentration is of 223777.2 MPs/km^2 (± 189829.6 MPs/km^2). This concentration should be seen as the minimum concentration of microplastics in the surface waters off the beach of Fondaco Parrino.

4. Summary

The preliminary results obtained on the 0.5 – 5.0mm fraction have shown that the concentrations are on average higher off the touristic beach of Giardini Naxos (493481.7 MPs/km^2 ± 40270.3 MPs/km^2), followed by the remote beach of Fondaco Parrino (22377.2 MPs/km^2 ± 189829.6 MPs/km^2) and the beach mainly used by locals of Letojani (49658.7 MPs/km^2 ± 8237.2 MPs/km^2). Further analysis are necessary to better understand the dynamic of the microplastics in the surface waters off Sicily.

II. Cyprus

1. Touristic beach: Sunrise

a) Sampling

Figure 125: *location map of the surface water sampling off the beach of Sunrise.*

Three surface water sampling were conducted off the touristic beach of Sunrise in June, July and August 2018 along the same two transects (**Fig. 125**). The sampling were realized parallel to the fixed 100m portion selected for the marine litter surveys and the sand sampling. A net for microplastic sampling, with a mesh size of 100µm and an opening of 0.7x0.4m, was deployed along the 1497m of the first transect and along the 1496m of the second transect. The net sampled a total surface of 2095.1m^2 for each of the three sampling. Following the procedure, the particles caught by the net were transferred into clean glass jars and immersed in ethanol. The samples were shipped to Barcelona, Spain, for the microplastics analysis.

b) Results

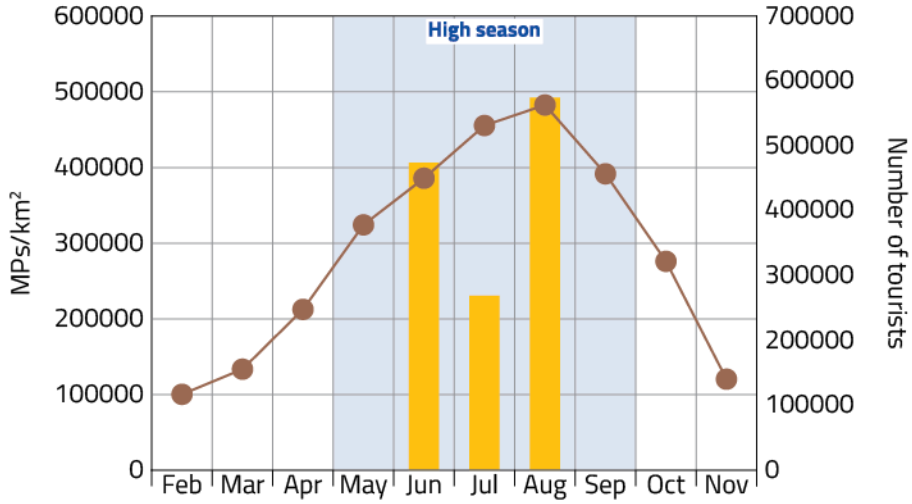

Figure 126: *concentrations of microplastics in the surface waters off the beach of Sunrise. Here only the particles of the 0.5 – 5.0mm are considered.*

The three surface water sampling off the beach of Sunrise show variable concentrations of microplastics ranging from 0.5 to 5.0mm (**Fig. 126**). As no samples were collected during the low

season, it is impossible to discuss a possible seasonal variation. The average concentration is of 376274.8 MPs/km^2 (± 108857.0 MPs/km^2). As only the 0.5 – 5.0mm fraction has been analyzed. This concentration should be seen as the minimum concentration of microplastics in the surface waters off the beach of Sunrise.

2. Beach mainly used by locals: Faros

a) Sampling

Figure 127: *location map of the surface water sampling off the beach of Faros.*

Three surface water sampling were conducted off the beach mainly used by locals of Faros in June, July and September 2018 along the same transect (**Fig. 127**). Due to the configuration of the beach, the sampling were not realized exactly parallel to the fixed 100m portion selected for the marine litter surveys and the sand sampling. A net for microplastic sampling, with a mesh size of 100µm and an opening of 0.7x0.4m, was deployed along the 3000m of the transects. The net sampled a surface of 2100 m^2 for each transect. Following the procedure, the particles caught by the net were transferred into clean glass jars and immersed in ethanol. The samples were shipped to Barcelona, Spain, for the microplastics analysis.

b) Results

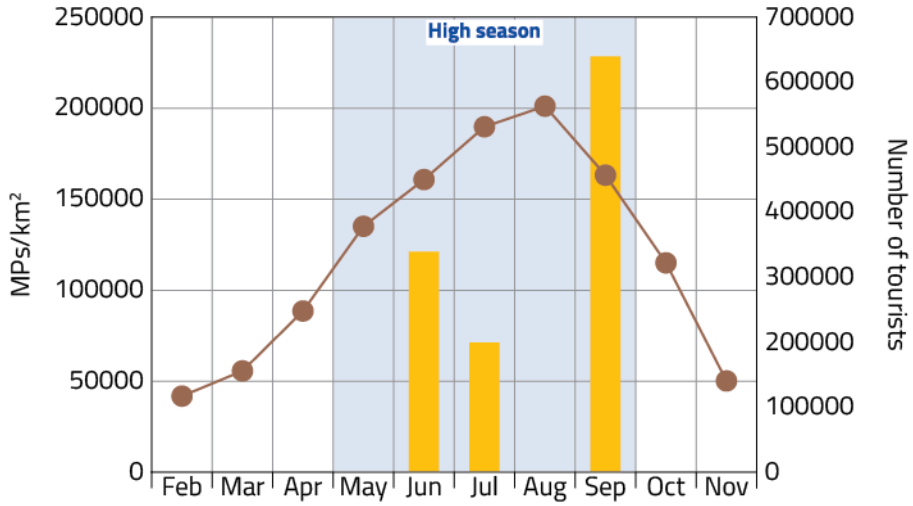

Figure 128: *concentrations of microplastics in the surface waters off the beach of Faros. Here only the particles of the 0.5 – 5.0mm are considered.*

The three surface water sampling off the beach of Faros show variable concentrations of microplastics ranging from 0.5 to 5.0mm (**Fig. 128**). As no samples were collected during the low season, it is impossible to discuss a possible seasonal variation. The average concentration is of 142698.4 MPs/km^2 (± 66739 MPs/km^2). As only the 0.5 – 5.0mm fraction has been analyzed. This concentration should be seen as the minimum concentration of microplastics in the surface waters off the beach of Faros.

3. Remote beach: Timi

a) Sampling

Figure 129: *location map of the surface water sampling off the beach of Timi.*

Three surface water sampling were conducted off the remote beach of Timi in June, July and November 2018 along the same two transects (**Fig. 129**). Due to the configuration of the beach, the sampling were not realized exactly parallel to the fixed 100m portion selected for the marine litter surveys and the sand sampling.A net for microplastic sampling, with a mesh size of 100µm and an opening of 0.7x0.4m, was deployed along the 1483m of the first transect and along the 1497m of the second transect. The net sampled a total surface of 2086m^2 for each of the three sampling. Following the

procedure, the particles caught by the net were transferred into clean glass jars and immersed in ethanol. The samples were shipped to Barcelona, Spain, for the microplastics analysis.

b) Results

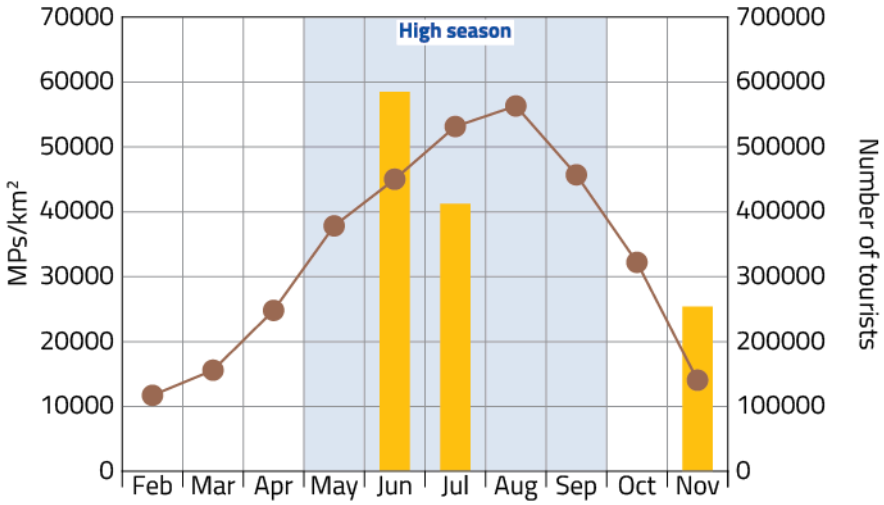

Figure 130: *concentrations of microplastics in the surface waters off the beach of Timi. Here only the particles of the 0.5 – 5.0mm are considered.*

The three surface water sampling off the beach of Timi show a decreasing of the concentrations of microplastics ranging from 0.5 to 5.0mm (**Fig. 130**) fromJune to November. It seems that the concentrations of microplastics are higher during the high season (49856.2 MPs/km^2 ± 8628.9 MPs/km^2) compared to the low season (25407.5 MPs/km^2). As only the 0.5 – 5.0mm fraction has been analyzed. This concentration should be seen as the minimum concentration of microplastics in the surface waters off the beach of Timi.

4. Summary

The preliminary results obtained on the 0.5 – 5.0mm fraction have shown that the concentrations are on average higher off the touristic beach of Sunrise (376274.8 MPs/km^2 ± 108857.0 MPs/km^2), followed by the beach mainly used by locals of Faros (142698.4 MPs/km^2 ± 66739.6 MPs/km^2) and the remote beach of Timi (41706.6 MPs/km^2 ± 13508.2 MPs/km^2). Regarding the remote beach of Timi, it seems that the concentrations of microplastics in the surface waters are higher during the high season (49856.2 MPs/km^2 ± 8628.9 MPs/km^2) than during the low season (25407.5 MPs/km^2). Further analysis are necessary to better understand the dynamic of the microplastics in the surface waters off Cyprus.

Part G: APPENDIX

I. Mallorca

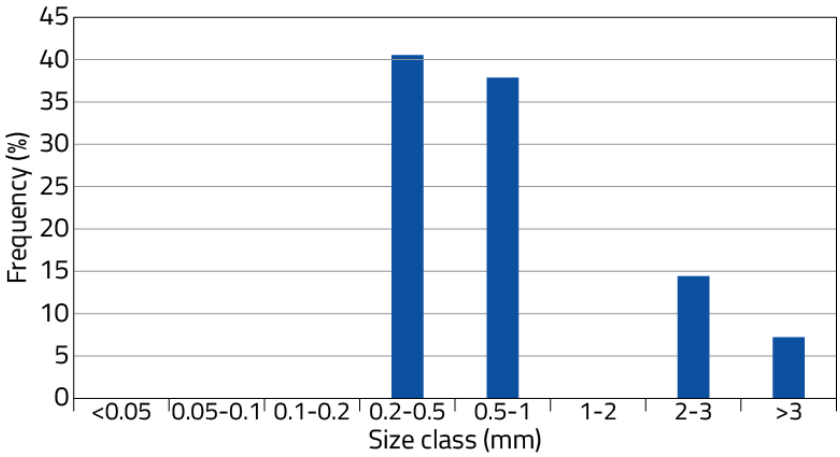

Figure 131: size distribution of the microplastics collected on the sand samples of the beach of Torà.

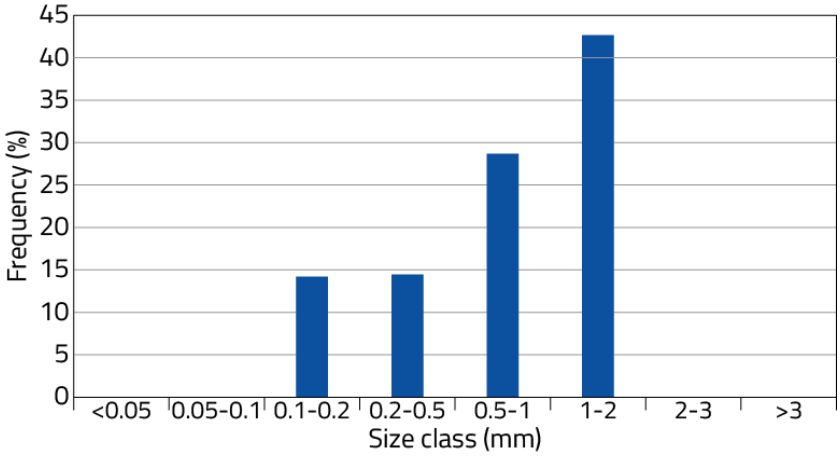

Figure 132: size distribution of the microplastics collected on the sand samples of the beach of Es Caragol.

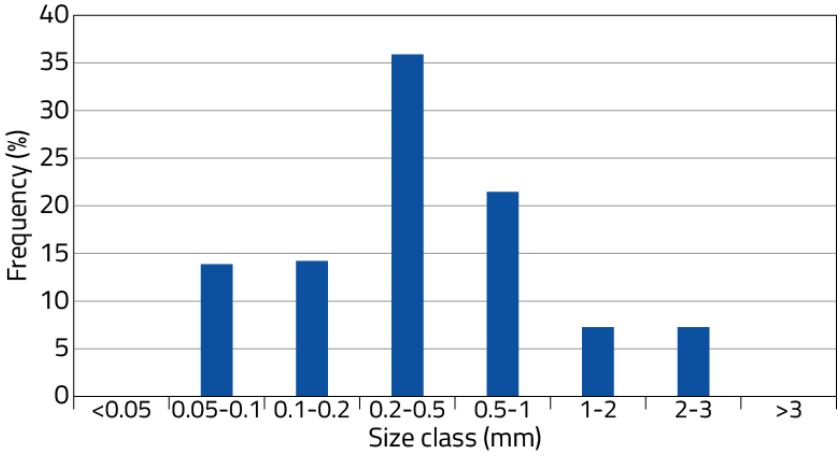

Figure 133: size distribution of the microplastics collected on the sand samples of the beach of Sa Canova.

II. Sicily

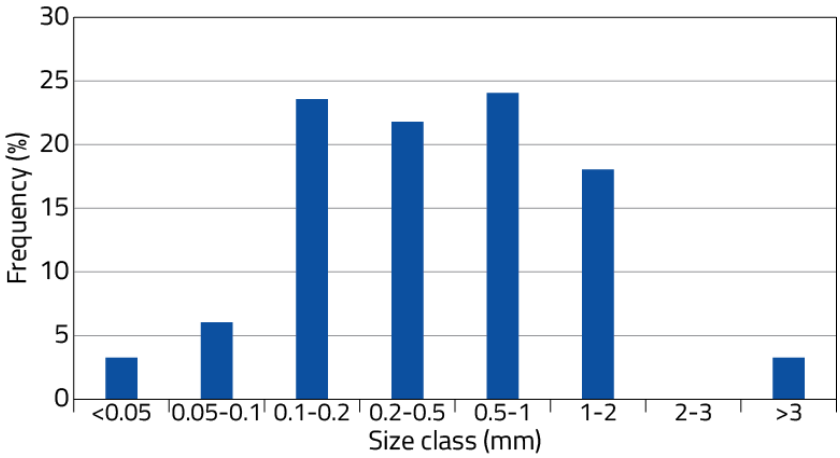

Figure 134: size distribution of the microplastics collected on the sand samples of the beach of Giardini Naxos.

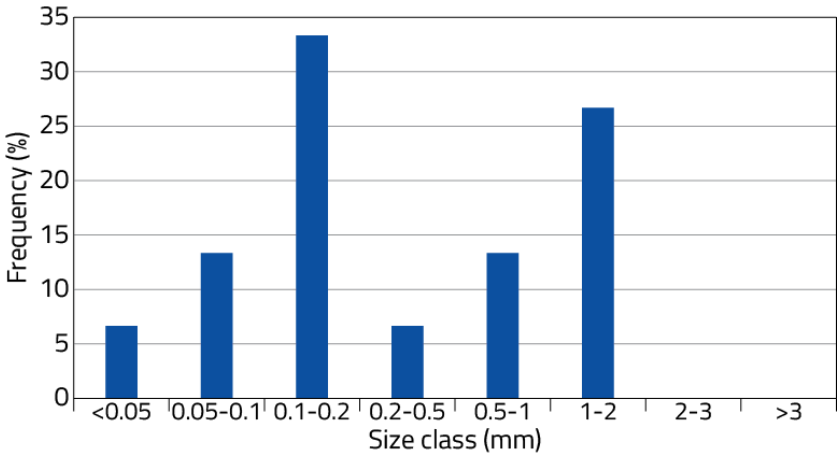

Figure 135: size distribution of the microplastics collected on the sand samples of the beach of Letojani.

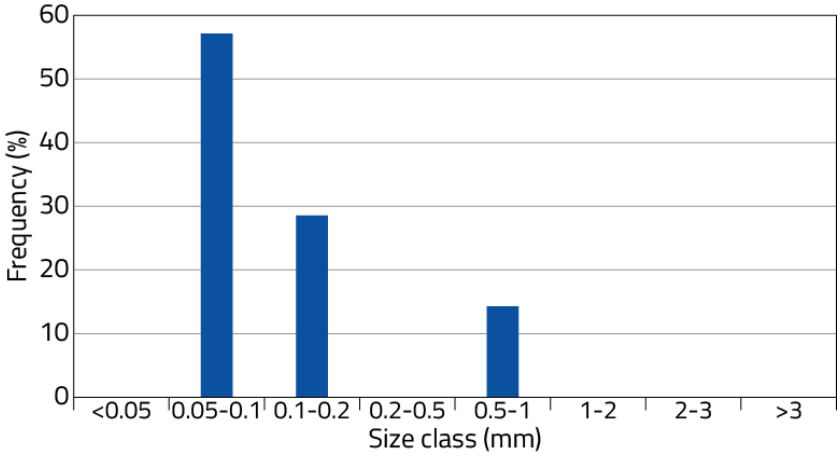

Figure 136: size distribution of the microplastics collected on the sand samples of the beach of Fondaco Parrino.

III. Rab

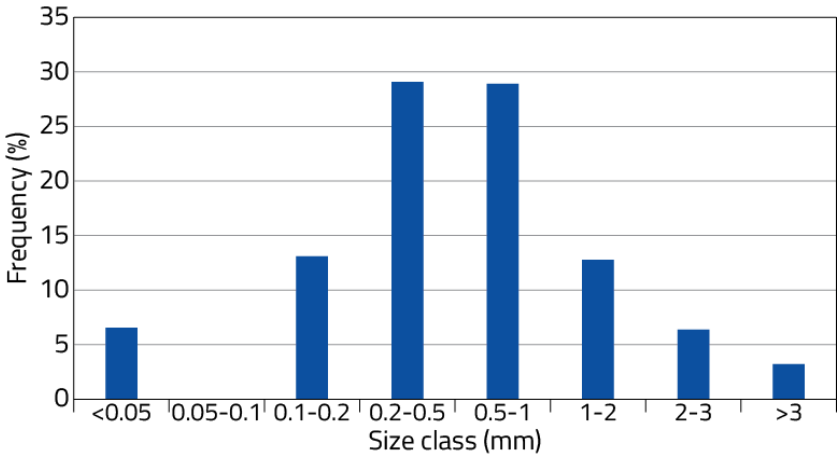

Figure 137: size distribution of the microplastics collected on the sand samples of the beach of Rajska.

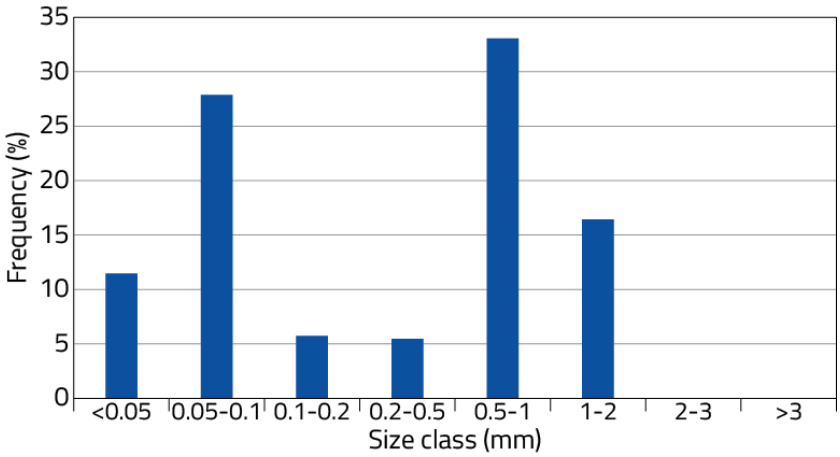

Figure 138: size distribution of the microplastics collected on the sand samples of the beach of Kampor.

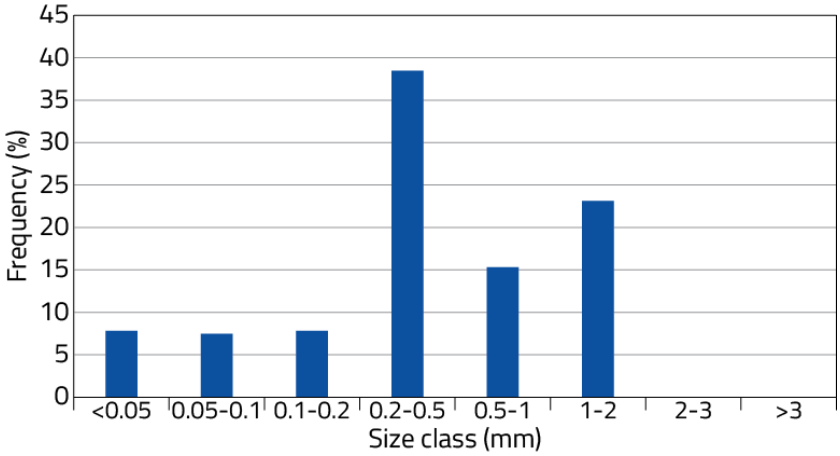

Figure 139: size distribution of the microplastics collected on the sand samples of the beach of Pudarica.

IV. Malta

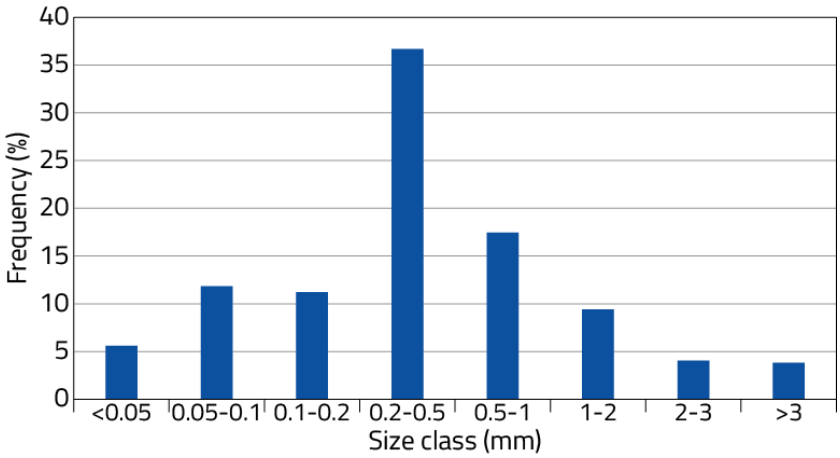

Figure 140: size distribution of the microplastics collected on the sand samples of the beach of Golden Bay.

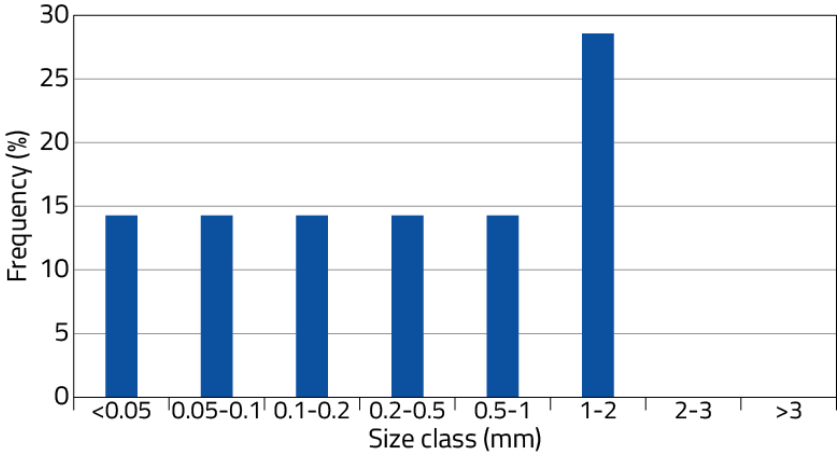

Figure 141: size distribution of the microplastics collected on the sand samples of the beach of Gnejna.

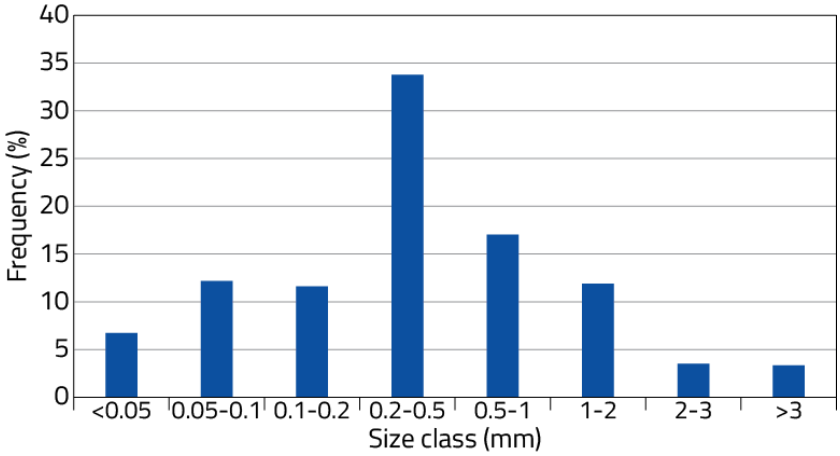

Figure 142: size distribution of the microplastics collected on the sand samples of the beach of Marsaxlokk.

V. Crete

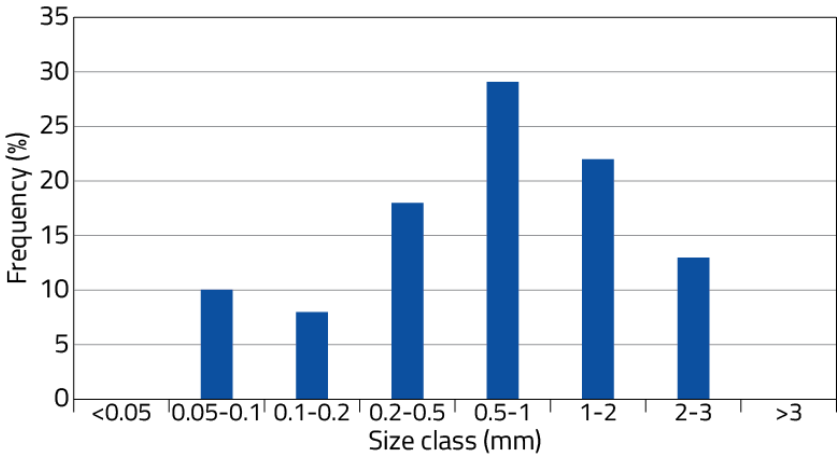

Figure 143: size distribution of the microplastics collected on the sand samples of the beach of Rethymno.

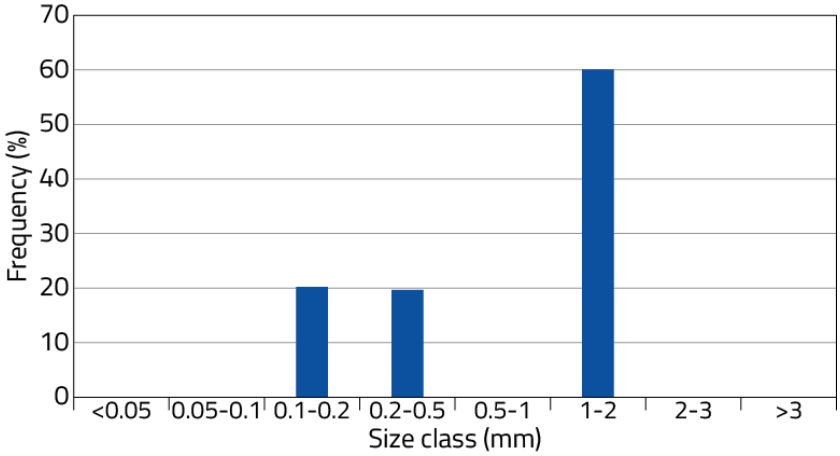

Figure 144: size distribution of the microplastics collected on the sand samples of the beach of Arina.

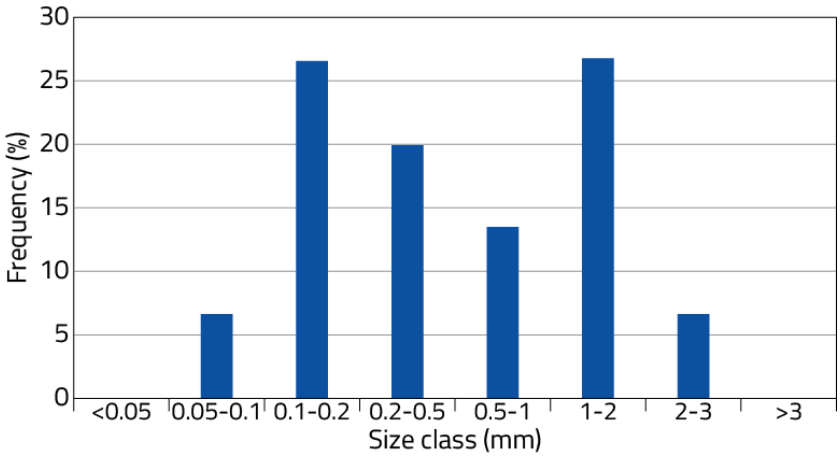

Figure 145: size distribution of the microplastics collected on the sand samples of the beach of Tsoutsouras.

VI. Mykonos

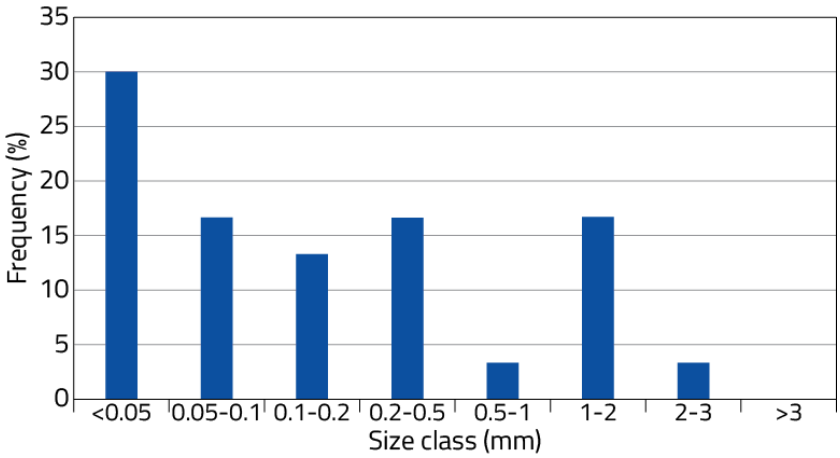

Figure 146: size distribution of the microplastics collected on the sand samples of the beach of Platis Gyalos.

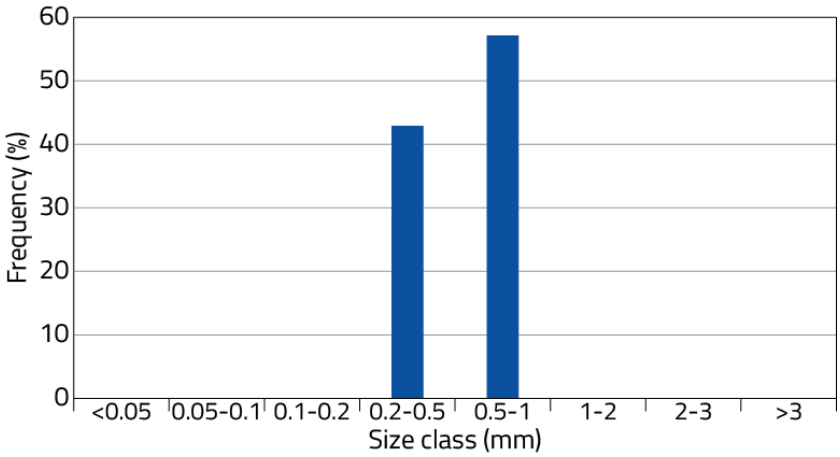

Figure 147: size distribution of the microplastics collected on the sand samples of the beach of Fokos.

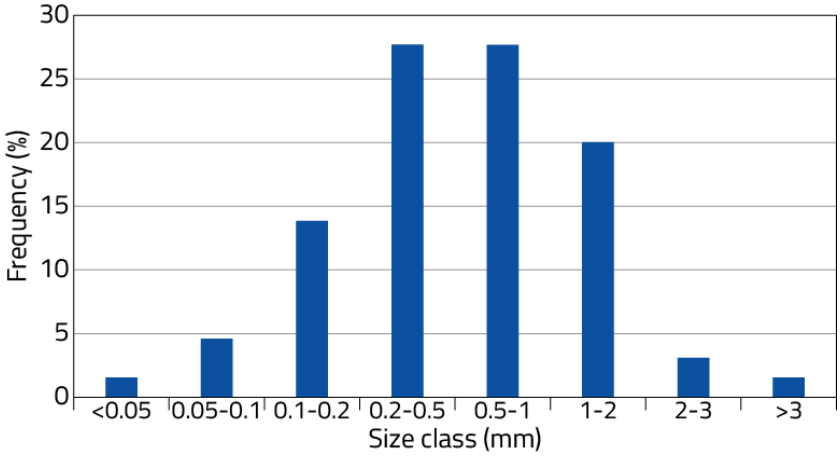

Figure 148: size distribution of the microplastics collected on the sand samples of the beach of Merchia.

VII. Rhodes

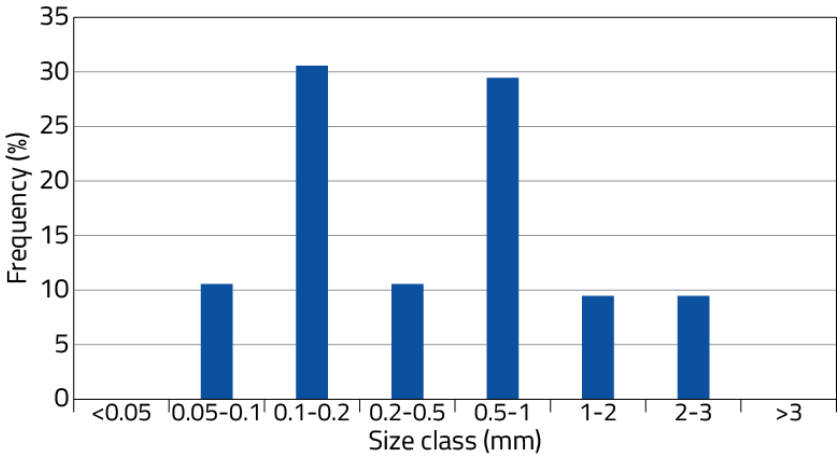

Figure 149: size distribution of the microplastics collected on the sand samples of the beach of Tsampika.

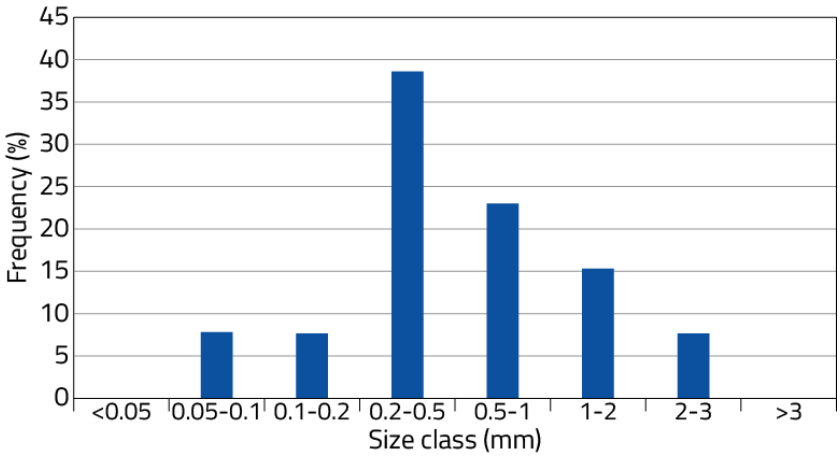

Figure 150: size distribution of the microplastics collected on the sand samples of the beach of Afandou.

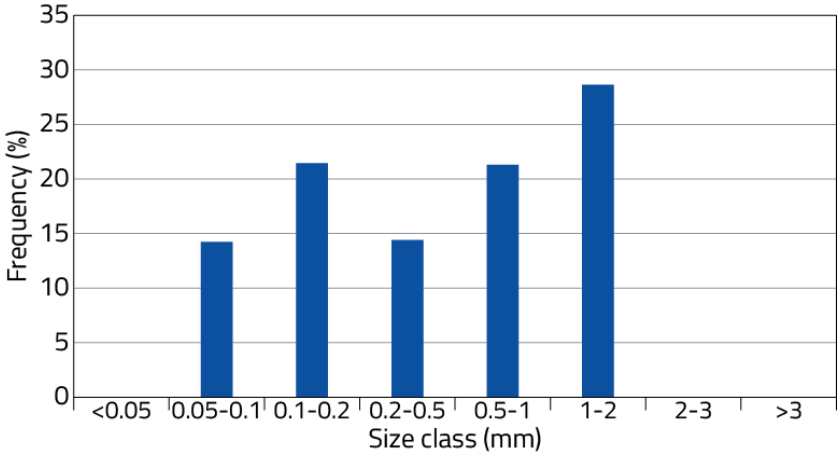

Figure 151: size distribution of the microplastics collected on the sand samples of the beach of Gennadi.

VIII. Cyprus

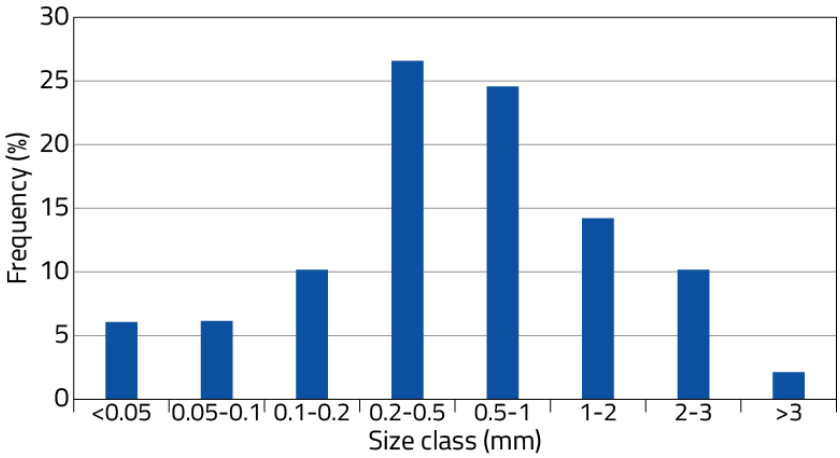

Figure 152: size distribution of the microplastics collected on the sand samples of the beach of Sunrise.

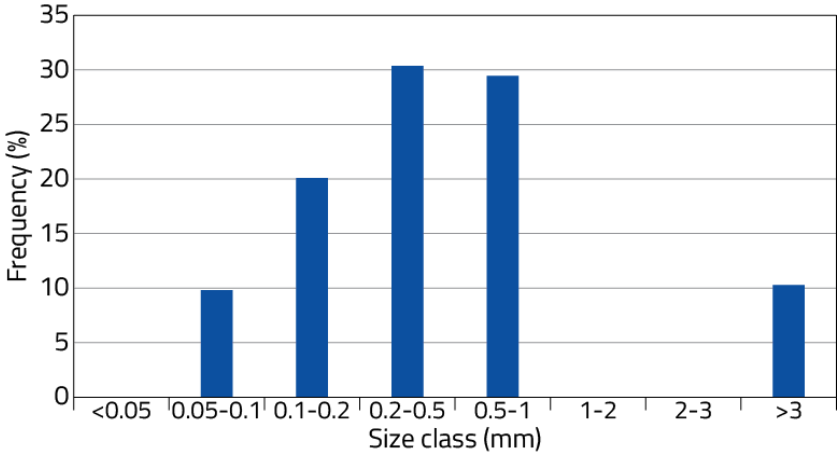

Figure 153: size distribution of the microplastics collected on the sand samples of the beach of Faros.

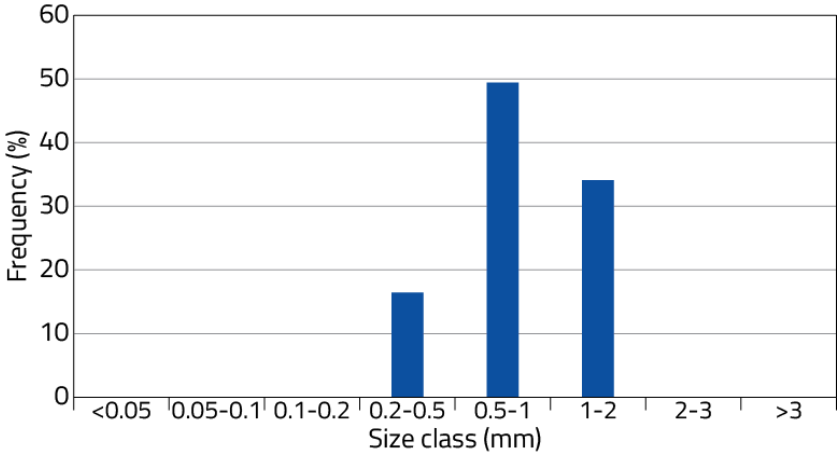

Figure 154: size distribution of the microplastics collected on the sand samples of the beach of Timi.