MICROPLASTICS ALONG THE COAST OF ZANZIBAR

This report is based on preliminary results from a screening of microplastics in surface water around Unguja, Zanzibar conducted in January 2019. It has been a collaboration project between the authors, State university of Zanzibar and "Building Stronger Universities programme Phase III project", Aarhus University's Work Package 2 "Marine and Coastal Ecosystem Health and Services (MaCES)".

Elisabeth Lundsør, Sara Rydbeck, Maneno Ibrahim Hamis, Shaib Silima Mnemba, Halima Mohammed Othman, Alli Nassor, Zhanna Tairova

Project title:	SCREENING FOR MICROPLASTICS ALONG THE COAST OF ZANZIBAR
Project leader:	Elisabeth Lundsør
Assistant project leader:	Sara Rydbeck
Other key personell:	Maneno Ibrahim Hamis, Shaib Silima Mnemba, Halima Mohammed Othman, Alli Nassor
Coordinator from BSU III:	Zhanna Tairova
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Background

In recent decades, marine anthropogenic litter pollution has been recognized as a serious global environmental concern (Bergmann et al., 2015). The global awareness of the plastic waste problem in our oceans, including marine microplastic litter is growing, so does the number of field studies characterising the actual amounts, composition and impact of micro-litter in the marine environment. However, the studies covering the waters on the East African coast are surprisingly few. Estimates are that there are between 15 to 51 trillion particles floating around. Although the Mediterranean and North Atlantic oceans have the highest numbers, the coast of East Africa seems to be an area with more plastic particles than other coasts of the Indian ocean. One of the main reasons for this situation is probably the lack of, or insufficient waste management in the area.

“Micro-litter” comprises a diverse group of particles including plastic and non-synthetic materials. Micro-litter, e.g. microplastics, are a category of marine litter, with the latter defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment (United Nations Environment Programme, 2005). For micro-litter there is now a general agreement that it concerns particles < 5 mm (Galgani et al., 2013).

Since microplastics can be ingested by a wide range of organisms, and there are indications that microplastics are propagated over trophic levels of the marine food web, scientists investigate whether the contamination of marine organisms with plastic particles, which also function as a vector for potentially harmful chemicals and microorganisms is causing harm to ecosystems and human health (Bergmann et al., 2015).

Microplastic can be divided into two overall groups, primary (engineered particles) or secondary microplastic (fragments of macroplastic litter), with the latter expected to be the most common microplastic in the sea (Leslie et al., 2011). The primary microplastic are more restricted to their uses in e.g. personal care products, industrial scrubs, industrial production of plastic (resin) pellets are used as raw material for production of various macroplastic items (Strand et al., 2015).The secondary microplastic can originate from fragmentation/degradation of macro-litter from various sea-based sources, e.g. fishing gear, aquatic recreations, and land-based sources, e.g. street litter, landfills, wastewater effluents and overflows, rivers, recreational activities at coastal zones (Leslie et al., 2011).

The knowledge of the different sources’ contribution to microplastic particles in the sea varies between different parts of the world and is limited. While studies in Finland and Sweden on effluents from waste water treatment plants (WWTPs) have indicated that these can be a significant source of micro-litter in the aquatic environments (Strand et al., 2015), the major contributing sources in Zanzibar will vary.

Characterisation of micro-litter, including microplastics, according to material, shapes, colour, and their amounts and distribution in water column and geographical location is necessary as the first step in the assessment of this type of pollution. The assessment of the type and amount of micro-litter pollution in the Zanzibar water column, together with the assessment of micro- and macro- marine litter from the coastal zone, has its goals and sources identification of this type of pollution, which ultimately is aimed for better environmental planning and protection.

In 2016 a small pilot study was carried out where water was sampled from 8 stations off the shore of Stonetown and nearby areas and analyzed for microplastics. The results show that the most common plastic particles found in these samples were black particles. These could possibly be rubber particles from tyres, but further analyses are needed to verify this hypothesis. Even though most particles are found close to town, the samples from the reference areas shows that there are plastic particles everywhere.

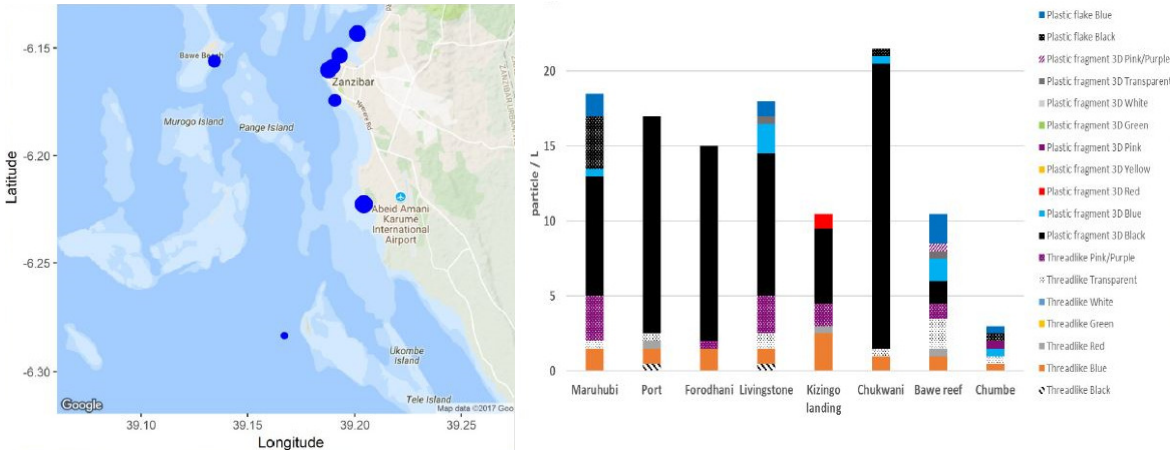

Figure 1: Results from a small microplastic sampling close to Stonetown in 2016.

In 2015 a series of baseline studies were initiated by the State University of Zanzibar (SUZA) and the University of Aarhus. These investigations include marine litter, microplastic, hazardous substances used as antifouling (Tributyltin, TBT, and Irgarol-1015), and metabolites of polycyclic aromatic hydrocarbons (PAHs) in fish bile. The studies are ongoing as a part of the environmental monitoring program. The results published on the marine litter beach survey, conducted according to UNEP guidelines (Cheshire and Adler, 2009) show that 369 kg of litter larger than 2.5 cm were collected along a 100 m long beach stretch and that the major litter material categories were “plastic”, “cloth” and “mixed material”.

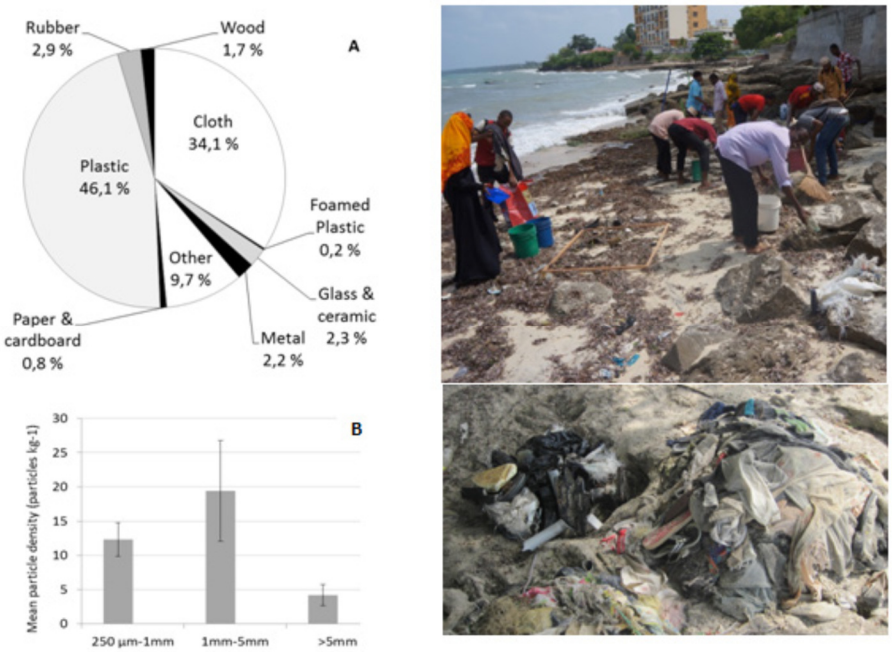

Figure 2: Marine litter survey along a 100 m beach stretch a few km north of Stone Town. The composition of large litter items (A) was characterized by weights (kg) in percent. The concentrations of microplastic and mesoplastic (5-25 mm) particles identified from beach sediments (B) were counted under a stereoscope and shown as mean ± standard error, n = 5. Photos by Z. Tairova and J. Strand.(Staehr et al., 2018).

Aim

An overall aim of this small project was to identify the most commonly found types of micro-litter in surface waters around Unguja island, Zanzibar. This study is also an attempt to show some results of the actual presence and quantity of microplastic around the island, since there are no previously known surveys done on microplastic in the surface waters around Zanzibar. To ensure the possibility for stable monitoring and analysis, the work was conducted in close collaboration with SUZA MSc students who participate in the MSc program under the Danish project BSU III, in the Work Package 2: Marine and Coastal Ecosystem Health and Services (MaCES), WP between State University of Zanzibar (SUZA) and Aarhus University (AU) and project supervisors. This collaboration pilot study is a part of a broader marine litter monitoring of the Zanzibar waters, in order to identify sources of marine litter pollution, for better environmental planning and protection of the coastal zone.

An additional goal of the project was to conduct the work in close collaboration with local scientific institutions as well as local organizations at civil society level and tourism enterprises, to enable different parties to meet and discuss actuality of microplastic pollution in Zanzibar coastal waters and the general problem of marine litter and waste management on Unguja island.

Methods

Site information

In order to investigate the amount and type of microplastic occurring along the coastline of Zanzibar, a small study was carried out taking samples at 5 different sites along the coast. The sites were situated outside Stonetown, in Fumba (Menai Bay), Jambiani and Matemwe as well outside Chumbe Island (Figure 3).

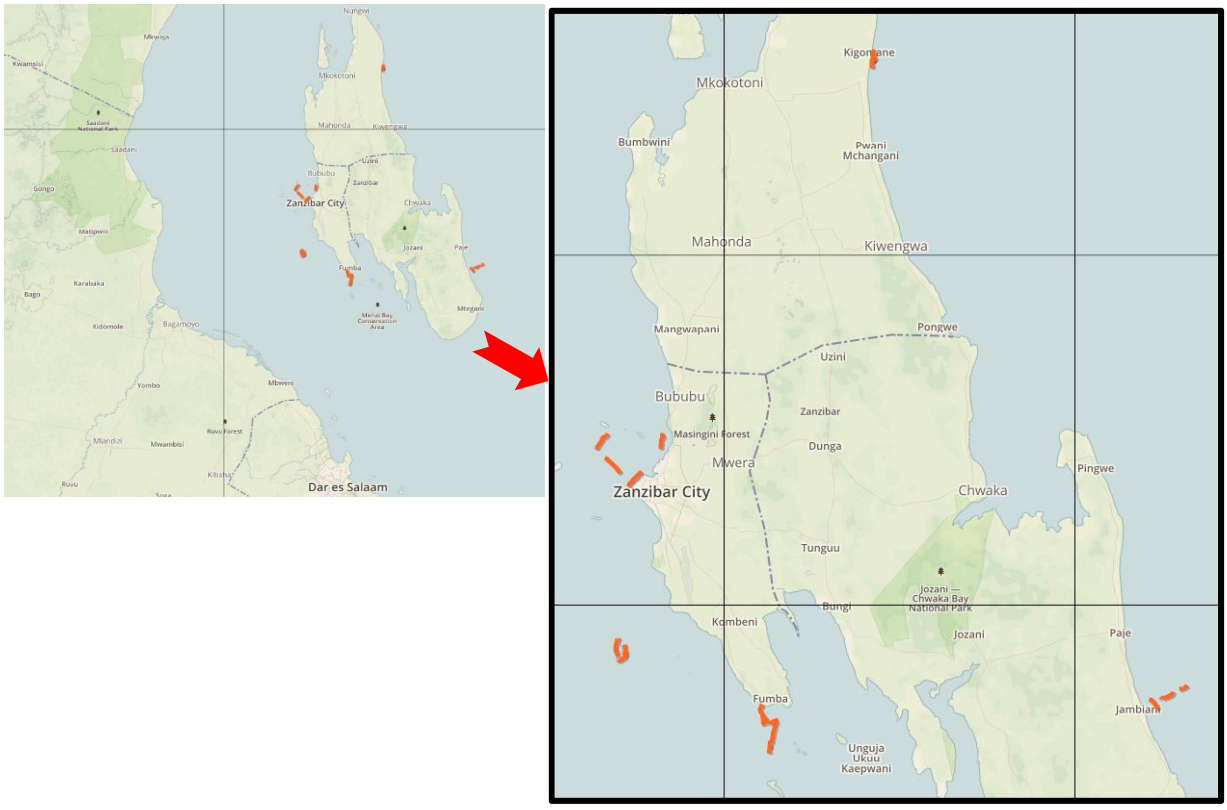

Figure 3: Map of location of sampling sites. Transects are plotted (orange dots) based on GPS coordinates.

Fumba (Menai bay)

Fumba is located at Menai Bay on the southwestern coast of Zanzibar. The village has mainly local inhabitants, but the northeast has an area with exclusive holiday houses recently been built and used by foreigners and wealthy Zanzibaris. At the beach of Fumba there is a lot of small boats, both local fishing boats as well as tour boats (Safari Blue). The tours boats are taking tourists around Menai Bay and to Kwale Island. The beach is heavily polluted by lots of different litter including plastics. The samples were taken along the main picnic area on Kwale Island, from the island towards Fumba beach as well as along the beach outside the village. The site is considered as moderately contaminated.

Jambiani

Jambiani is a village on the southeastern coast of Zanzibar. Approximately 2-3 km outside the village is a fringing reef which continues along the whole east coast of Zanzibar. Along the beach lots of hotels and restaurants are situated. The beach is both used by locals as well as a recreational area for tourists, with some boats used for fishing or recreational activities as diving, snorkeling, kite surfing etc. The beach gets cleaned regularly, but there are still some litter laying around. The samples were taken along the beach both inside and outside the reef as well from the reef towards shore.

Chumbe Island

Chumbe island is located 8 km south of Stonetown on the west coast of Zanzibar. Chumbe Island Coral Park (CHICOP) is a marine and terrestrial sanctuary protected since 1992. The island is used both for tourism and education, focused on conservation and sustainability. Along the west coast of the island is a coral reef within the protected area, while fishing etc. is allowed on the east coast. West of the island is the main shipping lane for ferries and cargo ships between Dar es Salaam and Zanzibar. The beaches of Chumbe Island are cleaned regularly. The samples were taken along the west, south and east side of the island.

Matemwe

Matemwe is a village on the northeastern coast of Zanzibar. Approximately 1-2 km outside the village is a fringing reef which continues along the whole east coast of Zanzibar. As in Jambiani there are lots of hotels and restaurants situated along the beach. The beach is both used by locals as well as a recreational area for tourists, with lots of boats used for fishing or recreational activities such as diving, snorkeling etc. The beach gets cleaned regularly, but there are still lots of litter laying around, especially outside the center of the local village. The samples were taken along the beach inside the reef as well diagonally from shore towards the reef.

Stonetown

Stonetown is located at the west coast of Zanzibar and is main town of the island. There are lots of domestic houses, official buildings, shops, hotels, airport and a variety of different activities. The main harbor and ferry terminal is situated in city center. The beaches and coastal waters outside town are strongly affected by pollution and waste from the sewage system (both wastewater as well as solid waste) and litter just thrown out by people. Outside the town are several small islands, out of which some are used for tourist activities, such as Prison Island and Chapwani Island, which contribute to the coastal pollution. Samples were taken along the main harbor, between Prison and Bawe island as well as from Prison Island towards the town. One sample was also taken outside Hotel Verde located at Mtoni, north of the city centre. Here a large hotel complex with an additional, waterpark, jetty and harbour is under construction, probably causing lots of run off and pollution from the building site. There are many contaminated sites, due to intensive land-based and aquatic activities at this location.

Sampling

The samples were, where possible, collected in the surface waters outside the sampling beaches which has already been investigated for microplastic or in areas of potential hot spot sources for micro-litter such as in Stonetown harbour, the city centre of Stonetown and Fumba village or the main picnic area for Safari Blue on Kwale island. The sampling site outside Chumbe Island was chosen as a site potentially not as affected by land-based micro-litter sources in comparison to the other sites. However, Chumbe Island is located in an area where the ocean currents may transport micro-litter from Dar es Salaam.

Figure 4. Picture of the manta trawl while trawling.

Samples were collected using a manta trawl, figure 4. A manta trawl is a small surface trawl, which consists of conical net attached to a metal case with 2 wings which makes sure the trawl stays fully open while trawling as well staying on the surface. Half of the manta net opening should be submersed during sampling. In the cod end of the trawl a 300 µm mesh is attached to a polypropylene tube with hose clamps. Individual mesh is used for each station. The trawl was deployed along the side of the vessel using a wooden stick, ropes, karabiners and blocks. The trawl was deployed at approximately 2-3 m distance from the boat in order to prevent collecting water affected by turbulence inside the wake zone.

The trawling was conducted with a speed of approx. 2 - 3 knots in a straight direction for 15 minutes, i.e. sampling along a transect. At each site 3 -4 samples (transects) were taken. During sampling, the position in tracked using a GPS. The GPS coordinates and time was written down at the start and the end of each transect in the data sheet. After trawling, the manta net was rinsed thoroughly from the outside of the net with seawater. Then the trawl was lifted out of the water and the net was rinsed with filtered freshwater. The net was rinsed in the direction from the manta mouth to the cod end in order to concentrate all particles adhered to the net into the cod end, se figure 5. Then the net was safely removed, and the organic material assembled in the polypropylene tube was transferred to a ziplock plastic bag marked with predefined site name and transect number. Finally, the net end of the tube was covered with aluminum foil and the filter at the cod end of the tube was removed and transferred to a separate ziplock plastic bag marked with predefined site name and transect number. The sample was stored in a plastic bag for further transport to the lab. The tube was rinsed with filtered freshwater in order to prevent contamination between transects and a new filter was attached to the cod end of the trawl with a hose clamp. The same procedure was repeated for each transect.

Figure 5. Sample in the cod end of the trawl with lots of organic material.

Analysis, characterization of particles

The analysis, aimed to characterize micro-particles was carried out in the scientific lab at Beitraz Campus, State University of Zanzibar using stereo microscopes. Prior to microscopic analysis, samples from manta trawl were prepared as follows:

- The samples were rinsed in freshwater in large metal bowls and a visual examination for microplastic was carried out. Most samples contained quite a lot of organic material, mostly seagrass but also pieces of plants, fish and shells.

- The particles, presumably plastic found in the samples were stored in labelled glass bottles.
- Then the samples were filtered through three different sieves with mesh size 5 mm, 1 mm and 0,3 mm.

-The content in the 5 mm sieve was examined for plastic particles in a stereo microscope and then put in a plastic bag marked with site name, sample number and date, together with the remaining organic material found. Theses samples were then stored in the freezer, preserving the samples for further analysis.

- The content in the 1,0 mm and 0,3 mm sieves were carefully transferred to marked petri dishes which were analyzed in a stereo microscope, (figure 7). The plastic particles found in the samples were then stored in glass bottles marked with site name, sample number, date and size (i.e. 1 mm or 0,3 mm).

- The same protocol was applied for the characterization of particles as for the analysis of microplastic in beach sediment conducted by SUZA/BSUIII. Particles were characterized according to the material, colour and size of the particles.

The results of the microscopy particle characterization analysis were conducted twice by different persons for quality control and for training of the personnel.

Figure 6. The samples were rinsed three times and a visual scan for microplastic particles was done before sieving the samples through three sieves with different sizes.

Figure 7. Analysis of samples in stereo microscopes.

Results

The preliminary results from the survey are summarized in Figure and Figure .

Figure 8 shows the total amount of particles found in each sample, divided in three different types, i.e. threads, fragments and films. Figure 10 shows pictures of different types of particles found. The samples are named after site and number of samples, i.e. Chumbe Island (Chumb 1-3), Fumba (Fumb 1-4), Jambiani (Jamb 1-3), Matemwe (Matw 1-3) and Stonetown (Town 1-4). This figure clearly shows that the highest amount of particles (130) was found in sample outside Stone“Town 1” which is the sample taken just outside the harbor of Stonetown. The lowest number of particles (3) was found in Fumba 2 (Fumb 2) which was taken outside the picnic area at Kwale Island. Another 5 stations had less than 10 particles, while the remaining 10 stations had between 20 and 60 particles.

Figure 9 shows the size distribution of the particles found in different samples. The figure shows that the largest particles are mostly found outside Stonetown, while the smallest particles are found around Chumbe Island located ca 8 km southwest of Stonetown. Mainly small particles were found in the samples taken at Fumba. In some samples from Jambiani and Matemwe there are most particles in size fraction 1 mm.

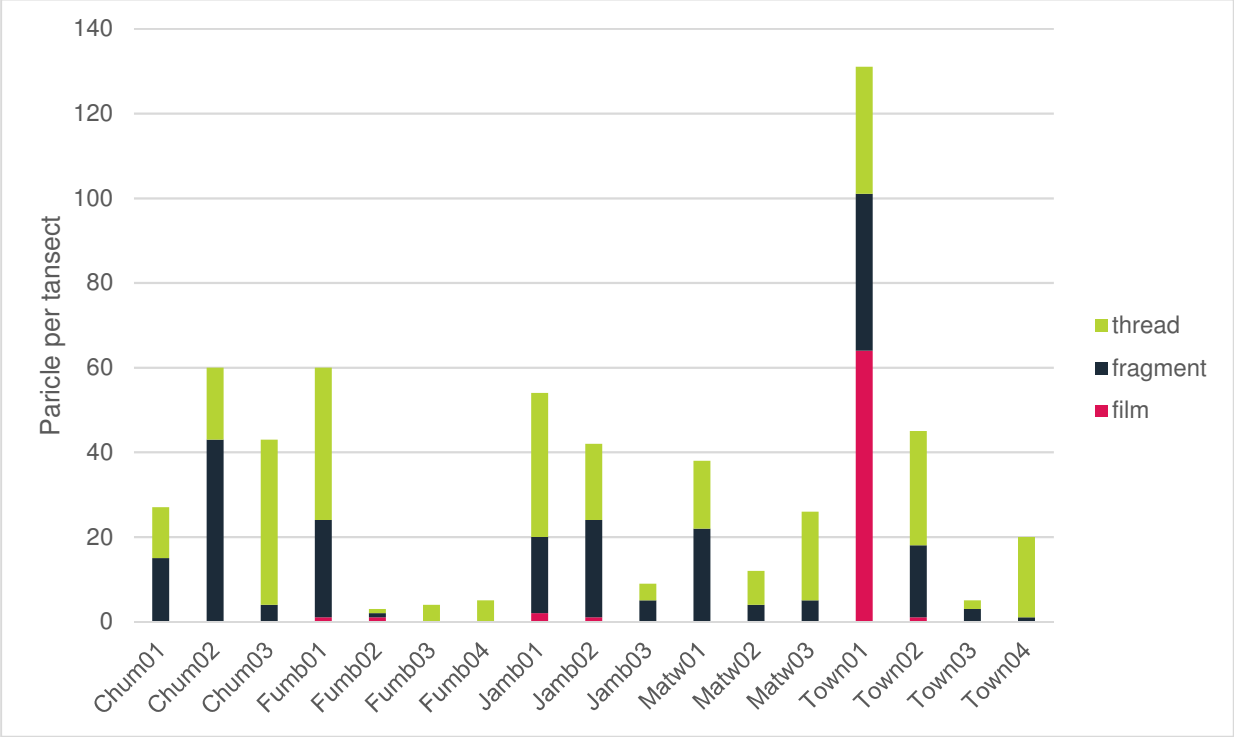

Figure 8: The total amount of particles per sample and the amount of different types of particles within each sample.

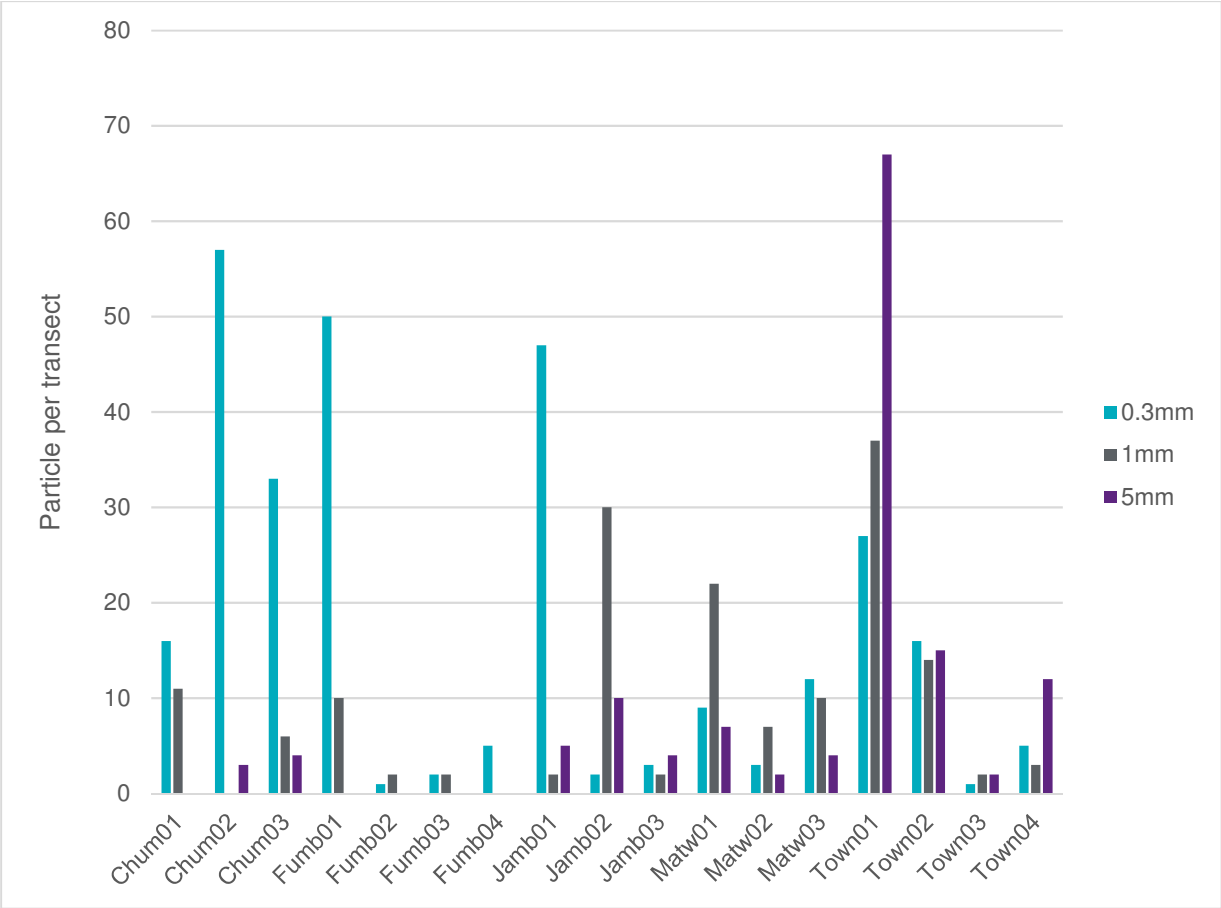

Figure 9: The distribution of particles of different size fractions in the different samples.

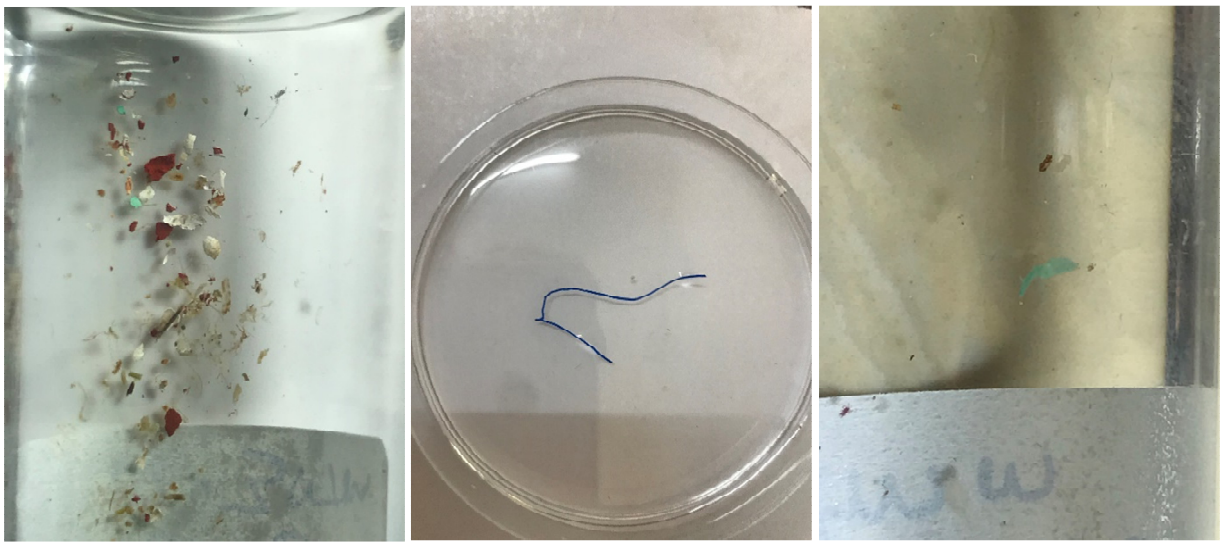

Figure 10. Pictures of different types of microplastics found in the samples, from left to right several fragments, a thread and a film.

Chumbe Island:

The samples taken around Chumble Island contained mainly small particles (i.e. 0.3 mm). Most particles were found in the sample taken on the eastern side of Chumbe island, i.e. the side facing town where fishing is allowed (Chum02). The sample consisted of a mixture of particles, but mainly of fragments and threads. Most fragments might be paint from boats. Some of the paint particles might originate from the boat used for our sampling, but since the fragments had different colours and differed between the three samples taken from the same boat, the fragments might originate from

other boats used in this area. Least particles were found on the western, protected side (Chumb01) of the island. This sample contained approximately equal amount of threads and fragment. The sample taken south of the island (Chum03) consisted of mostly threadlike particles and few fragments.

Fumba

At 3 out of 4 samples taken at Fumba, there were only a few particles found in each sample (< 5 particles/sample) which made Fumba the site where least microplastic particles were found. At this site, no large fractions of plastic (>5 mm) were found. However, in the first sample (Fumb01), taken south east of Kwale Island, there were approximately 60 particles found. The sample was dominated by small blue threads, possibly from clothes, ropes of fishing lines and black particles. Most of the particles found were in the size fractions 0.3 mm. These results show how unevenly the microplastic particles are distributed within the surface water ad that the abundance can vary greatly between sites located just a few hundred meters apart. The large variation can be due to several reasons such as currents, winds, distance from shore etc.

Jambiani

At Jambiani, two transect were taken parallel to the beach both inside (Jamb01) and outside (Jamb02) of the fringing reef as well as one transect taken perpendicular from the reef towards the beach (Jamb03). In the two samples taken along the shore a similar amount and type of particles were found, but there was a big difference in size fractions where the sample from inside the reef was dominated by smaller size fractions while mainly larger particles dominated the sample from outside the reef. The sample from outside the reef was dominated by blue fragments. In the sample taken perpendicular to the beach, only a few threads and fragments were found. This may be due to the current which normally goes parallel to the coast.

Matemwe

At Matemwe, all the transects were taken inside of the fringing reef due to the windy conditions at the time of sampling. Two transects were taken parallel to the beach (Matw01, Matw02) and one transect was taken diagonal from the beach towards the reef (Matw03). The three samples had a similar mixture of threads and fragments as well as s variety of all size fractions. However, in the first sample (Matw01) taken at the northern end of Matemwe, close to Kigomani, a higher amount of large particles (>.5 mm) was found.

Stonetown

Outside Stonetown, two transects were taken close to the coast and parallel to the beach, outside the harbor (Town 01) and outside the building site of Hotel Verde at Mtoni (Town02). In addition, one transect was taken further out between Prison Island and Bawe and one transect was taken perpendicular towards beach outside the city center. Stonetown was the site where most microplastic particles were found, especially at the transect taken close to town, i.e. just outside the harbor and Forodani (Town01). In this sample more than twice the number of particles was found than in any of the other samples taken. The sample contained the highest number of larger pieces of plastic (i.e. film), probably originating from bags or sheets of plastic, but also a high amount of white fragments believed to be styrofoam as well as some threadlike particles from ropes etc. Also, the sample taken outside Mtoni (Town01) contained a fairly high number of particles but consisted mostly of threads and fragments evenly distributed between different size fractions. The other samples (Town03, Town04) were taken further offshore and it seemed like the further away from town, the less particles were found, with the smallest number of particles found in the sample taken between Prison Island and Bawe.

Conclusions and recommendations

This report shows the preliminary results from a trawl screening conducted at five study sites around Unguja island, Zanzibar. The highest number of particles found was at the site close to Stonetown. Here we found a big variety of particles, both larger films possibly from plastic bags as well as styrofoam fragments from packing material, together with threads and fibers possibly from fishing nets, lines and ropes. Similar threadlike particles were also found around Chumbe Island, outside Jambiani and Matemwe as well as on the southeastern side of Kwale Island. In addition, these sites also had a fairly high amounts of fragments possibly originating from boat paint. Three of the samples taken at Fumba in Menai Bay differs from the other samples taken in this survey in their low number of particles mainly consisting of threads.

The plastic particles found were mainly originating from paint, plastic bags or other packing material together with pieces of heavier plastic such at plastic containers and threads expected to originate from fishing and boat gear. The particles probably originate from local activities and waste from Zanzibar but the particles may also originate from other countries as well as from shipping, which have been transported to the coast of Zanzibar through different currents and sea level patterns.

In comparison with surveys from other parts of the world, and also compared to the authors experience from surveys outside Oslo, the capital of Norway, the number of particles found around Zanzibar are at similar levels as moderate polluted areas elsewhere.

This small survey is only an attempt to give an indication of the situation concerning microplastics in surface waters around Zanzibar. In order to be able to draw stronger conclusions from the survey, we recommend further sample collection and analysis on a regular basis, i.e. a regular monitoring program. The overall goal of this study was to conduct a pilot survey, analyse the data locally, and prepare a short report as well as a presentation in close collaboration with SUZA and other local organizations and private companies. Hence this collaborative activity is not be considered as a full scientific study.

However, by further analysis of the data from this survey, both concerning types of plastic material as well as differences in currents and sea level patterns around the island, a better understanding of the situation can be achieved. By giving our samples to the SUZA MSc students working with the Danish project “BSU III” in the Work Package 2: Marine and Coastal Ecosystem Health and Services (MaCES), WP between State University of Zanzibar (SUZA) and Aarhus University (AU), we hope further analysis can be carried out from which more accurate results can be given.

There is a global need to reduce the amount of plastic in the oceans in order to ensure the survival of marine ecosystems and the biodiversity of the oceans. As the first step in the environmental risk assessment, in order to achieve the common goals of plastic pollution reduction, the regular monitoring, aimed to characterize the extent of the pollution and in order to find the pollution sources can be conducted by collaboration between scientific institutions and non-scientific initiatives, i.e. local NGOs. To be able to reduce the amount of plastic in the ocean both around Zanzibar and elsewhere in the world it is essential to prevent the plastic, both macro- and microplastic from entering the sea. Various solutions to the reduction of marine plastic pollution include a combination of reducing the consumption of the single-use plastic materials and extensive development of the local waste management, the problem which is more actual especially in developing countries. The work has to be carried out in close collaboration between governments, the local communities, organizations and private companies.

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