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Presence of microplastics in benthic macroinvertebrates along the Kenyan coast

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Microplastics (MPs) are plastics less than 5 mm in diameter. Their small size renders them invisible to deposit- and filter-feeding fauna, leading to unintentional ingestion. This study investigated the presence of MPs in an oyster (*Saccostrea cucullata*) and three species of brachyuran crabs (*Tubuca dussumieri*, *Cranuca inversa* and *Gelasimus vocans*) along the Kenyan coast. Sampling was carried out at eight stations distributed between three sites: Tudor, Port Reitz and Mida creeks, in January and February 2018, during low spring tide. The sample comprised 206 crabs and 70 oysters. Samples were digested using 10% KOH at 60 °C for 24 hours and then passed through 38-µm sieves. Sieved products (<38 µm) were filtered through Whatman filter membranes (0.8 µm) and viewed under a dissecting microscope for MPs. The study identified mainly MP fibres, which were of different colours: red, yellow, black, pink, orange, purple, green, blue and colourless. Colourless fibres were the most prevalent, comprising at least 60% of the total MPs. Mean lengths of MPs fibres of different colours were between 0.1 and 4.2 mm. The mean concentration of MPs (MPs g^{-1} wet tissue) was 0.65 (SE 0.13) in crabs and 3.36 (SE 0.53) in oysters, and the difference between the two taxa was significant (independent two-sample *t*-test: $t = 5.61$, df = 14, $p = 0.01$). The higher mean concentration in oysters was attributed mainly to their filter-feeding habit. This study exposes MP pollution along the Kenyan coast and its uptake by marine fauna, and thus strengthens the case for better control of plastic wastes in the ocean.

Keywords: deposit feeders, East Africa, filter feeders, genus *Uca*, ingested microplastics, marine fauna, plastic pollution, *Saccostrea cucullata*

Introduction

Plastic waste is categorised into two broad classes: microplastics (MPs) and macroplastics (Bråte et al. 2017). Macroplastics are large, readily visible plastic pieces, whereas MPs are small plastic particles less than 5 mm in diameter (Bråte et al. 2017). MPs are further categorised as either primary or secondary MPs (Boucher and Friot 2017). Primary MPs are designed specifically to be small (Wright et al. 2013); they include materials such as resin, plastic powders, scrubbers and microbeads (EFSA 2016). Conversely, secondary MPs typically result from the fragmentation of larger plastic items through abrasion, wave action or photo degradation (Eriksen et al. 2014; Brennecke et al. 2015).

According to Jambeck et al. (2015) about 8 million tonnes of plastics enter the world's oceans yearly. The main pathways of these plastics are stormwater run-off, rivers and streams, wastewater discharges and transportation of land litter by wind, as well as through recreational and commercial fishing gear (Avio et al. 2017). Land-based sources are estimated to contribute about 80% of marine plastic litter (Smith et al. 2018).

Marine plastic pollution is a global concern because of the effects of plastics on marine fauna, including through entanglement and ingestion (Wilcox et al. 2015). Of particular concern are the MPs that are unintentionally ingested, especially by filter- and deposit-feeding invertebrates, such as oysters and crabs, which cannot distinguish the particles from their regular food and are unable to digest them (Lusher et al. 2017).

The concentration of MPs in marine fauna can be determined by examination of the gut contents. In most cases, the concentration is expressed in terms of the number of particles per gramme wet weight or the number of particles per individual organism (EFSA 2016). A study by Van Cauwenberghe and Janssen (2014) found an average concentration of 0.47 ± 0.16 particles of MPs per gramme of tissue (wet weight) in Pacific oyster *Crassostrea gigas*. Most of these MPs were fibres. Recently, the mean concentration of microfibres in fiddler crabs was found to be 11.6 microfibres per crab in the fall and 5.9 microfibres per crab in the spring (G Forbes and E Rosch 2019, Coastal Carolina University, unpublished data[1]).

Ingestion of MPs by sea fauna can cause blockage of or damage to the digestive tract, resulting in reduced feeding (Hoss and Settle 1990; Wilcox et al. 2015). Moreover, MPs may concentrate chemical pollutants such as persistent organic pollutants that can be leached into body tissues

[1]Forbes G, Rosch E. 2019. Microplastics in fiddler crabs (genus *Uca*). Honours thesis, Coastal Carolina University, South Carolina, USA. Available at https://digitalcommons.coastal.edu/honors-theses/337

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upon ingestion (Galloway 2015) and cause poisoning, infertility and disruption of the genetic makeup of organisms that consume them (Forster 2016). MPs ingested by lower organisms such as zooplankton are likely to be passed on to higher organisms in the food chain, leading to their bioaccumulation (Katija et al. 2017).

It was hypothesised that crabs and oysters at several locations on the Kenyan coast would contain MPs in their tissues. The aim of this study was to test this hypothesis and to measure and compare the concentrations of MPs in filter-feeding oysters and deposit-feeding crabs that are consumed directly by humans and also act as food for fish of economic importance.

Materials and methods

Field methods

Sampling was carried out during spring low tides, between 31 January and 3 February 2018. Three sites were chosen on the Kenyan coast (Tudor, Port Reitz and Mida creeks) and a total of eight stations were sampled: (i) Tudor Creek – at Mikindani, Kenya Meat Commission (KMC), Nyali Bridge, and English Point; (ii) Port Reitz Creek – at Makupa, Mwache Tsunza, and Mwache SGR; and (iii) Mida Creek – at Dabaso. The stations were selected based on the perceived prevalence of plastic pollution and the occurrence of the target invertebrates. Tudor and Port Reitz creeks are located close to the town of Mombasa, and therefore are considered to be exposed to relatively high levels of plastic pollution, whereas Mida Creek is located in Watamu Marine National Park, which is distant from Mombasa. Three replicate samples consisting of 5 to 20 individuals of each species were collected randomly from the stations. Oysters were removed from surfaces to which they were attached using a chisel, while crabs were obtained through handpicking and extracting them from their holes using a shovel. Samples were placed in airtight glass bottles and transferred to an insulated box for further analysis in the laboratory.

No permit was required to euthanise the samples as no policy or guidelines are in place regarding the use of invertebrates for scientific research in Kenya, with existing regulations pertaining only to vertebrates (Kimwele et al. 2011).

Laboratory methods

The samples of crabs were rinsed with distilled water to remove any contaminants attached to the carapace. Species were identified based on their morphology, following Mangale and Kulkami (2013). Individuals were measured for carapace length (cm) using Vernier callipers, and weighed (g) using a kitchen scale. Samples from each station were then combined and crushed using a mortar.

The samples of oysters were rinsed with distilled water to remove biofilms on their surface (Lusher et al. 2017). All the oysters collected were identified as *Saccostrea cucullata* (Born, 1778), using guides by Anam and Mostarda (2012) and Watson (2018). The length (longest shell length, cm) of individuals was measured using Vernier callipers, and each was weighed (g) using a kitchen scale. Samples were then frozen to facilitate deshelling.

Microplastics processing

Organic tissues were digested following the method of Lusher et al. (2017). Each sample was placed in a clean beaker and a solution of 10% KOH was added until the sample was completely submerged. Samples were incubated at 60 °C for 24 h. The digestion of crabs was incomplete after 24 h, and therefore a second quantity of 10% KOH was added, and these samples were incubated for a further 12 h. Digested samples were passed through a 38-µm sieve. Materials that passed through the sieve were filtered through Whatman filter membranes (0.8 µm). The membranes were dried in an oven at 60 °C for 12 h, and then examined for MPs under a dissecting microscope. Suspected MPs were placed in a glass petri dish and their identification confirmed using a hot-needle test, in which plastic material melts and shrinks upon heating. The MPs were classified according to their shape, colour and length. Because of their microscopic size, there was no attempt to identify the polymers comprising the plastics.

Laboratory quality control

Sample contamination was minimised using the following techniques: (i) using glass equipment; (ii) rinsing all equipment with distilled water before use; (iii) testing the distilled water for MPs; (iv) wearing a cotton lab coat; and (v) working with minimum movement in the laboratory. A filter membrane was placed in a petri dish on the work table to act as a control for airborne MPs; upon viewing the filter under a dissecting microscope, no MPs were observed, and therefore minimal risk of plastic contamination was assumed.

Statistical analysis

Data analysis was carried out using the package 'Rcmdr' in RStudio 3.6.3 (R Core Team 2020). First, the data were tested for normality using a Shapiro–Wilk test and were found to be normally distributed. A one-way ANOVA was used to compare the lengths of MPs of different colours obtained from the samples, followed by a Tukey HSD *post hoc* test to identify differences among the colours of MPs ($p < 0.05$). The mean concentration of MPs was calculated as the number of MPs per gramme wet tissue. The mean concentration values for crabs and oysters were compared using an independent two-sample *t*-test; differences were considered significant at $p < 0.05$. A correlation analysis was performed to determine the correlation between the mean concentration of MPs and the mean weight of the organisms.

Results

Distribution of organisms

Crabs occurred at seven of the eight stations studied (Mikindani, KMC, Nyali Bridge, Makupa, Mwache Tsunza, Mwache SGR and Dabaso), the exception being English Point. A total of 206 individuals of brachyuran crabs were sampled, and three species were identified: *Tubuca dussumieri* (H. Milne Edwards, 1852), *Gelasimus vocans* (Linnaeus, 1758), and *Cranuca inversa* (Hoffmann, 1874). *Tubuca dussumieri* was the dominant species, accounting for 66% of the collection, and was found at all stations where crabs were collected apart from Mwache

SGR. *Cranuca inversa* was encountered only at Makupa and Dabaso, whereas *G. vocans* occurred only at Mwache SGR (Table 1). Mean lengths for *T. dussumieri* by station ranged between 1.3 and 1.8 cm; the means were 1.0 and 1.3 cm for *C. inversa*, and 1.6 cm for *G. vocans*. Mean weights ranged between 2.7 and 9.9 g for *T. dussumieri*, and were 1.5 and 3.3 g for *C. inversa*, and 5.5 g for *G. vocans* (Table 1).

Oysters were encountered at three of the eight stations: English Point (n = 28), Mwache Tsunza (n = 5) and Dabaso (n = 37). All the oysters were identified as *Saccostrea cucullata* (Born, 1778). At Mwache Tsunza and Dabaso, oysters were found attached to the stems of mangrove trees, whereas those at English Point were found attached to rocks on the shore. Oysters at Mwache Tsunza were encountered at a single point, and hence there were no replicates at this station. Mean shell lengths ranged between 4.3 and 6.2 cm, and mean weights of the de-shelled tissue ranged between 0.8 and 3.4 g. The mean lengths and weights of oysters differed between sites (length: F[1, 4] = 16.87, p = 0.01; weight: (F[1, 4] = 35.29, p = 0.04), with oysters from English Point being longer (6.20 cm [SE 0.33]) and heavier (3.39 cm [SE 1.96]) than those from Dabaso and Mwache Tsunza.

Microplastic occurrence in crabs and oysters

Seven different colours of MP fibres were obtained from the crab samples: black, blue, green, purple, red, yellow and colourless. In crabs, colourless fibres were the most prevalent at 60%, whereas purple and yellow fibres were the least recorded at 1% each (Figure 1). The mean lengths of MPs differed significantly between colours (F[6, 133] = 5.97, p < 0.05); green (3.9 mm), blue (4.2 mm) and colourless (3.45 mm) fibres were significantly longer than purple (0.45 mm) and yellow (0.6 mm) fibres (Table 2). Stations, however, had no significant impact on the size of MPs of the same colour (F[6, 133] = 0.97, p = 0.45), except for Makupa where the green fibre was significantly longer than that at other stations (F[4, 5] = 0.06, p = 0.01) (Table 3).

The mean concentrations of MPs in crabs by station ranged between 0.13 and 1.24 MPs g^{-1} wet tissue in

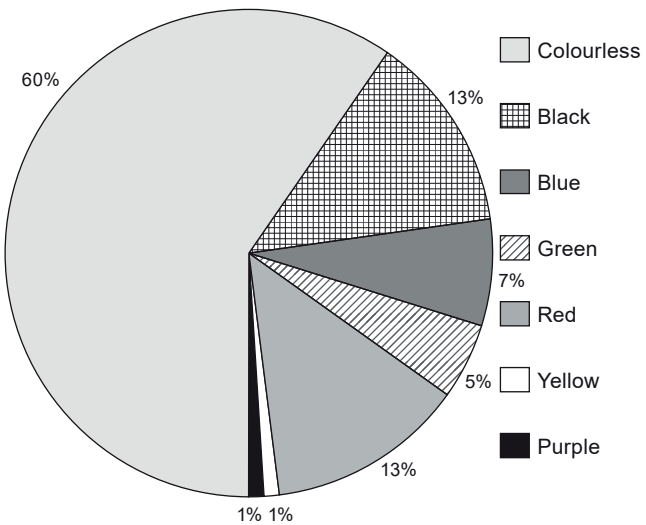

Figure 1: Percentages of different colours of microplastics found in three species of brachyuran crabs sampled on the Kenyan coast in January/February 2018

Table 1: Mean (SE) lengths and weights of crabs and oysters collected from the eight stations studied along the Kenyan coast in January/February 2018

Site	Station	Mean length (cm)	Mean weight (g)
	Tubuca dussumieri (n = 136)		
Tudor Creek	Mikindani	1.46 (0.10)	4.73 (1.40)
	Kenya Meat Commission	1.33 (0.02)	3.49 (0.20)
	Nyali Bridge	1.56 (0.01)	5.68 (0.21)
Port Reitz Creek	Makupa	1.80	9.88
	Mwache Tsunza	1.61 (0.02)	7.31 (0.74)
Mida Creek	Dabaso	1.65 (0.06)	5.75 (0.08)
	Cranuca inversa (n = 18)		
Port Reitz Creek	Makupa	1.26	3.29
Mida Creek	Dabaso	1.05	1.50
	Gelasimus vocans (n = 52)		
Port Reitz Creek	Mwache SGR	1.58	5.51
	Saccostrea cucullata (n = 70)		
Tudor Creek	English Point	6.20 (0.33)	3.39 (1.96)
Port Reitz Creek	Mwache Tsunza	4.31	0.80
Mida Creek	Dabaso	4.67 (0.18)	1.40 (0.08)

Table 2: Mean (SE) length (mm) of microplastic fibres of different colours extracted from tissues of three species of brachyuran crabs collected on the Kenyan coast in January/February 2018

Colour	Black	Blue	Colourless	Green	Purple	Red	Yellow	F(6, 133)	p-value
Length	2.30 (0.36)^{AC}	4.20 (1.06)^{C}	3.45 (0.46)^{C}	3.90 (0.83)^{C}	0.45 (0.31)^{A}	3.10 (0.58)^{BC}	0.6 (0.35)^{AB}	5.97	<0.05

Means followed by the same uppercase letters are not significantly different (Tukey pairwise comparisons of means: $p \leq 0.05$)

Table 3: Mean (SE) length (mm) of microplastics of different colours found in three species of brachyuran crabs sampled at different stations along the Kenyan coast in January/February 2018. KMC = Kenya Meat Commission

Station	Colour							df	*F*-value	*p*-value
	Black	Blue	Colourless	Green	Red	Purple	Yellow			
Nyali Bridge	2.02 (0.30)^{aA}	4.90 (2.95)^{aA}	3.18 (0.41)^{aA}	2.62 (1.51)^{aA}	2.25 (1.14)^{aA}	2.00 (2.00)^{aA}	2.00 (2.00)^{aA}	6, 14	0.38	0.88
Dabaso	1.5 (1.49)^{aA}	1.00 (0.99)^{aA}	4.60 (2.34)^{aA}	2.25 (1.88)^{aA}	6.02 (2.53)^{aA}	–	–	4, 14	1.99	0.14
KMC	3.67 (1.58)^{aA}	1.81 (1.81)^{aA}	3.54 (0.61)^{aA}	5.25 (1.14)^{a}	3.08 (0.41)^{aA}	0.50 (0.5)^{aA}	–	5, 14	2.68	0.07
Makupa	1.31 (0.19)^{aA}	3.38 (0.37)^{aA}	2.25 (0.25)^{aA}	9.00 (3.00)^{bA}	1.25 (1.25)^{A}	–	–	4, 5	0.06	0.01
Mikindani	2.83 (0.30)^{aA}	8.00 (2.64)^{aA}	5.17 (1.86)^{aA}	7.17 (2.42)^{aA}	3.50 (1.95)^{aA}	0.50 (0.5)^{aA}	–	5, 12	2.32	0.11
Mwache SGR	3.01 (0.25)^{aA}	6.90 (5.60)^{aA}	2.57 (0.20)^{aA}	1.00 (1.00)^{aA}	3.43 (0.62)^{aA}	–	2.00 (1.00)^{aA}	5, 12	0.72	0.62
Mwache Tsunza	1.66 (0.91)^{aA}	2.87 (0.33)^{aA}	2.45 (0.37)^{aA}	2.00 (2.00)^{aA}	2.37 (0.82)^{aA}	–	–	4, 12	1.67	0.20
F(6, 13)	0.82	0.85	0.79	2.86	1.39	0.92	1.21			
p-value	0.58	0.56	0.59	0.05	0.29	0.51	0.36			

Means within columns followed by the same lowercase letters are not significantly different; means along rows followed by the same uppercase letters are not significantly different (Tukey pairwise comparisons of means: $p \leq 0.05$)

Table 4: Mean (SE) concentration of microplastics (MPs g^{-1} wet tissue) in three species of brachyuran crabs and *Saccostrea cucullata* collected at different sites along the Kenyan coast in January/February 2018

Site	Station	Mean MP concentration
	Tubuca dussumieri	
Tudor Creek	Mikindani	1.24 (0.32)
	Kenya Meat Commission	0.51 (0.11)
	Nyali Bridge	1.16 (0.84)
Port Reitz Creek	Makupa	0.13
	Mwache Tsunza	0.28 (0.18)
Mida Creek	Dabaso	0.90 (0.13)
	Cranuca inversa	
Tudor Creek	Makupa	0.52
Mida Creek	Dabaso	0.33
	Gelasimus vocans	
Port Reitz Creek	Mwache SGR	0.79
	Saccostrea cucullata	
Tudor Creek	English Point	2.94 (0.88)
Port Reitz Creek	Mwache Tsunza	5.75
Mida Creek	Dabaso	2.99 (0.24)

T. dussumieri, 0.52 and 0.33 MPs g^{-1} wet tissue in *C. inversa*, and was 0.79 MPs g^{-1} wet tissue in *G. vocans* (Table 4); however, the differences between species were not significant (F[2, 17] = 0.23, p = 0.8). The study also found no correlation between the mean weights of crabs and the mean concentrations of MPs in their tissues (r[15] = 0.12, p > 0.20).

Eight colours of MPs were obtained from the oyster samples: black, blue, green, purple, red, pink, yellow and colourless. In oysters, colourless fibres were similarly dominant, accounting for 69% of the total number of MPs. Occurrences of the remaining colours were: red 12%, black 11%, blue 3%, green 3%, yellow 1%, pink 0.9% and purple 0.1% (Figure 2). The mean lengths of the different colours of fibres in oysters ranged between 0.11 and 3.16 mm; the differences in length between colours of MPs were significant (F[7, 48] = 8.19, p < 0.05) (Table 5), with colourless fibres being the longest (3.16 mm) and pink and purple fibres the shortest (0.11 mm and 0.21 mm, respectively). Site had no influence on the lengths of fibres in oysters (F[2, 53] = 0.89, p > 0.42) (Table 6).

The mean concentrations of MPs in oysters from the three stations were: 5.75 MPs g^{-1} wet tissue at Mwache Tsunza, 2.99 (SE 0.24) MPs g^{-1} wet tissue at Dabaso, and 2.94 (SE 0.88) MPs g^{-1} wet tissue at English Point. Mwache Tsunza was subsequently excluded from the analysis as oysters were only encountered at a single point. There was a significant difference in the mean concentrations of MPs in oysters from Dabaso and English Point (F[1, 4] = 0.95, p < 0.01), with oysters from Dabaso having the highest mean (2.99 [SE 0.24] MPs g^{-1} wet tissue). There was no correlation between the mean weights of oysters and the mean concentrations of MPs in their tissue (r[6] = 0.08, p > 0.54).

Discussion

This study supports the hypothesis that microplastics (MPs) are being ingested by deposit- and filter-feeding

macroinvertebrates (crabs and oysters) along the Kenyan coast. The findings suggest that MPs could be widespread in waters along the Kenyan coastline and might pose a risk to the marine fauna that ingest them unintentionally. Our findings conform with those of KMFRI (2018) regarding the abundance of MPs in Kenya's marine environment. However, there has not been any previous attempt to investigate the presence of MPs in macroinvertebrates, such as crabs and oysters, along the Kenyan coast; this study therefore presents the first evidence of the ingestion of MPs by marine macroinvertebrates found within coastal creeks where subsistence fisheries take place in Kenya.

The presence of MPs in oysters and crabs is of great concern as these organisms are an economically important food source for humans globally (BLASTIC 2018). Oyster meat is consumed whole, and therefore consumption of these organisms could lead to the transfer of MPs in their tissues to humans, which could have health implications. As stated by Hammer et al. (2012), Galloway (2015) and Naidoo (2017), MPs often concentrate chemicals that may be leached into the digestive fluids and transferred to other body tissues; such chemicals may cause poisoning, infertility and disruption of the genetic makeup of organisms. However, further research is needed to better understand the health risks of the ingestion of MPs by humans.

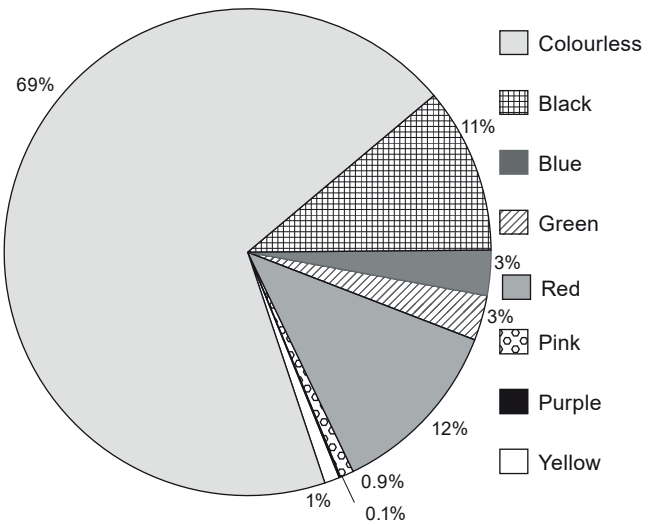

Figure 2: Percentages of different colours of microplastics found in oysters *Saccostrea cucullata* sampled on the Kenyan coast in January/February 2018

Our study sites were selected based on the occurrence of the target organisms and a perceived prevalence of plastic pollution. The main sites of focus were those bordering Mombasa, Kenya's largest port and second-most-populous city, which were chosen because of the growing human population in this coastal region, including high inputs of solid waste from the tourism and industrial sectors (Tan 2012). Mida Creek was used as a control site owing to its distant location from Mombasa and likelihood to be less influenced by human activities.

All the oyster and crab samples obtained in this study contained MPs, which consisted mainly of fibres. The dominance of fibres as MPs is consistent with other studies in locations across the globe, such as the work of Cole et al. (2014), Naidoo et al. (2016) and Waite et al. (2018). The MPs were of different colours (black, blue, green, red, yellow, pink, purple and colourless), which is an indication that the plastics were from multiple sources. Possible sources of MPs entering the creeks include urban surface run-off, coastal tourism, fisheries, wastewater treatment plants, shipyards, rivers, synthetic textiles, and personal-care products (Graca et al. 2017). Of all the colours, colourless fibres were the most common, indicating that the creek waters are contaminated particularly with plastics of this type. The study also noted that all the colours of MPs recorded were taken in by both oysters and crabs, other than pink, which was specific to oysters; it is possible that the pink MPs were concentrated only in those areas where oysters were obtained.

Table 5: Mean (SE) length (mm) of microplastic fibres of different colours in oysters *Saccostrea cucullata* collected on the Kenyan coast in January/February 2018

Colour	Black	Blue	Colourless	Green	Pink	Purple	Red	Yellow	*F*(7, 48)	*p*-value
Length	2.34 (0.18)^{AC}	2.26 (0.42)^{AC}	3.16 (0.47)^{C}	1.82 (0.51)^{AC}	0.11 (0.08)^{A}	0.21 (0.21)^{A}	2.79 (0.55)^{BC}	1.11 (0.48)^{AB}	8.189	<0.05

Means followed by the same uppercase letters are not significantly different (Tukey pairwise comparisons of means: $p \leq 0.05$)

Table 6: Mean (SE) length (mm) of microplastics of different colours ingested by oysters *Saccostrea cucullata* collected at different stations along the Kenyan coast in January/February 2018

Station	Black	Blue	Colourless	Green	Pink	Red	Yellow	*F*(7, 32)	*p*-value
Dabaso	2.25 (0.12)^{aBC}	2.91 (0.08)^{Abc}	2.45 (0.19)^{Abc}	1.62 (0.87)^{aB}	–	3.80 (0.09)^{bC}	1.11 (0.48)^{aB}	21.11	<0.05
English Point	2.19 (0.35)^{aAB}	1.36 (0.71)^{aAB}	3.91 (0.98)^{Ab}	2.62 (0.40)^{aAB}	0.43 (0.25)^{A}	2.69 (0.54)^{aAb}	2.60 (0.13)^{aAB}	4.47	<0.05
Mwache Tsunza	3	3	3	–	–	–			
F(2, 4)	1.22	2.76	1.09	1.93	–	12.10	1.81		
p-value	0.39	0.18	0.42	0.26	–	0.02	0.26		

Means (SE) within columns followed by the same lowercase letters are not significantly different; means along rows followed by the same uppercase letters are not significantly different (Tukey pairwise comparisons of means: $p \leq 0.05$)

MP fibres ingested by oysters were less than 5 mm in length, whereas those in crabs measured up to 9 mm. The finding of shorter MPs in oysters might be attributable to strong ocean currents within the water column where filter feeding occurs, acting on plastic particles and breaking them into smaller pieces. This finding might also be a consequence of the size difference between oysters and crabs, such that crabs, owing to their bigger mouths, are able to ingest larger particles than oysters.

The mean concentrations of MPs varied significantly between the oyster and crab samples, with higher concentrations observed in oysters (3.36 vs 0.65 MPs g^{-1} wet tissue). This variation might be influenced by the different feeding mechanisms of these two taxa. According to Zhou et al. (2014), bivalves such as oysters have a strong water-filtration capacity and can sieve several cubic meters of water to obtain sufficient plankton (Tilley 2018). Moreover, the filtration process tends to generate currents that concentrate materials, including MPs, in the water, thus increasing their availability to the filter feeders. Furthermore, it is possible that more MPs accumulate in the water column than in sediments, which renders filter feeders more vulnerable to these pollutants as compared with deposit feeders.

The presence of MPs in the oyster and crab samples from Mida Creek, located in Watamu Marine National Park, reveals the transboundary nature of MPs to the extent that even nature reserves bounded by ocean are affected. In fact, the mean concentration of MPs was higher at Dabaso (in Mida Creek) than at both Makupa and Mikindani. MPs at Dabaso might have originated from tourism activities in the region or been transported into the creek by ocean currents.

Conclusions

This study has shown that MPs are being ingested by marine biota, particularly oysters and crabs, along the Kenyan coast. Our findings indicated that oysters consume more MPs than crabs, which is probably attributable to their filter-feeding habit. The MPs found in the crabs and oysters consisted primarily of fibres, which were of different colours, suggesting that they originated from multiple sources. Colourless fibres were the most prevalent MPs in the samples, which suggests higher contamination of these types of fibres on the Kenyan coast. MPs can concentrate chemicals such as persistent organic pollutants that can cause infertility, disruption of the genetic makeup, and poisoning when consumed. The consumption of oysters especially may have implications to human health because MPs in this seafood may be passed into humans directly. Hence, we advocate for the development of proper management strategies and practices to reduce plastic pollution in the environment, particularly in the oceans. We also recommend further investigations to establish (i) in which specific body parts of the invertebrates the MPs are concentrated and (ii) the polymers from which the MPs are constituted.

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