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Covid-19-derived plastic debris contaminating marine ecosystem: Alert from a sea turtle

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ABSTRACT

On 10 August 2021, a face mask (14 cm × 9 cm) was found in the feces of a juvenile green turtle, by-caught alive in a set net off the northeast coast of Japan. Although sea turtles have been monitored in this region over the last 15 years ($n = 76$), face masks had never been found before the Covid-19 pandemic and this is the first detection. Fourier-transform infrared spectroscopy identified the mask as polypropylene. Estrogenic active benzotriazole-type UV stabilizers such as UV329 were detected in commercially available polypropylene face masks. Exposure of marine organisms ingesting plastics to endocrine-disrupting chemicals and physical injury are of concern. This study indicates that changes in human life in the pandemic are beginning to affect marine life. Precautionary actions including establishment of appropriate waste management of personal protective equipment and use of safe additives are urgently needed.

The Sars-CoV-2 (Covid-19) coronavirus pandemic has made drastic changes to human lives since January 2020 (Nicola et al., 2020). During the pandemic, the consumption of personal protective equipment (PPE) such as face masks has increased substantially. Some such items escape appropriate waste management and end up in the ocean (Prata et al., 2020; Parashar and Hait, 2021). This improperly discarded PPE has become a concern as a threat to marine life (Hiemstra et al., 2021; Gallo Neto et al., 2021).

On 10 August 2021, a face mask (14 cm × 9 cm, Fig. 1) was found in the feces of a juvenile green sea turtle, *Chelonia mydas* (38.5 cm straight carapace length, 8 kg body mass), by-caught alive in a commercial set net off the northeast coast of Japan. A sea turtle monitoring survey has been conducted in this region (38°55′-39°40′N, 141°40′-142°05′E), over the last 15 years (Narazaki et al., 2015; Fukuoka et al., 2015). By-caught turtles (mainly loggerhead and green turtles) are brought to the International Coastal Research Center of the Atmosphere and Ocean Research Institute, The University of Tokyo (39°21′05″N, 141°56′04″E), in Otsuchi town, Iwate Prefecture, Japan. The turtles captured alive were kept in individual tanks for up to 3 months to collect their feces. Dead turtles (<5% of captured turtles; Narazaki et al., 2015, Fukuoka et al., 2015) were dissected to observe the gut contents. Previous analyses of feces (28 loggerhead and 25 green turtles) and gut contents (13 loggerhead and 10 green turtles) analyses in this region revealed higher debris ingestion ratio than other regions around the world (Fukuoka et al., 2016). However, face masks had never been found before the pandemic and this is, unfortunately, the first detection.

In this study, items in the fecal samples were classified and identified to the lowest taxonomic level possible by visual examination, following Fukuoka et al. (2016). The wet mass of each sample was weighed to 0.1 g on a digital scale. The mask and other debris in the fecal sample were subjected to Fourier -transform infrared spectroscopy (FTIR) analysis to identify polymer types. To examine potential exposure of endocrine-disrupting additives, we bought 5 brands of face masks on the market and chemically analyzed them. The masks were extracted with n-hexane according to Sakuragi et al. (2021). The extracts were acetylated and purified by silica gel column chromatography and benzotriazole-type UV stabilizers were analyzed by gas chromatography–mass spectrometry according to Yamashita et al. (2021). Reproducibility and recovery were confirmed in advance through four replicate analyses of hexane-extracts of a polyurethane bottle with and without spiking of native benzotriazole-type UV stabilizers standards. The relative standard deviations of concentrations of individual benzotriazole-type UV

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Fig. 1. The face mask found in the feces of a green sea turtle.

Table 1
Wet mass (grams and % of total mass) of materials in the fecal sample.

Category	Wet mass (g)	% of total mass
Animalia		
Arthropoda		
Maxillopoda		
Pedunculata	2.3	5.4
Plantae		
Phycophyta		
Phaeophyceae		
Fucales		
Sargassaceae		
Sargassum	0.3	0.7
Angiospermae		
Monocotyledoneae		
Alismatales		
Zosteraceae	0.4	1.0
Other material		
Bird feathers	0.1	0.2
Wood fragments	3.3	7.7
Stone	1.3	3.0
Unknown	0.1	0.2
Artificial debris	35.1	81.8
Total	42.9	100

stabilizers were <5% and the recoveries were >81%. A procedural blank using only solvent was run with the set of samples. Analytical values less than 3 times that of the blank were considered below the limit of quantification (LOQ) shown as gray shading.

FTIR analysis identified the mask as polypropylene, a common material used in disposable face masks. The total 42.9 g of fresh feces held 35.1 g (81.8% of the total mass) of artificial debris, including the mask; 3.3 g (7.7%) of natural debris (wood fragments); and 2.3 g (5.4%) of Pedunculata (gooseneck barnacles) (Table 1). Other items (*Sargassum*, Zosteraceae, natural debris) were found in small amounts (<2 g, Table 1). These items have been found in previous dietary study in this region (Fukuoka et al., 2016). The polymers in the artificial debris were identified as plastic (mainly polypropylene and polyethylene) which considered to have floated or drifted near the surface owing to their low density. Wood fragments and gooseneck barnacles can float or be attached to drifting materials. Sea turtles often ingest floating or drifting debris near the surface (Casale et al., 2008; Fukuoka et al., 2016). Hence, we considered that this turtle ingested the drifting face mask while feeding near the surface.

As the pandemic continues, the usage of disposable PPE continues. Unless appropriate waste management is instituted, the ingestion of PPE and its breakdown products, such as microplastics, will increase in a variety of marine life very soon (Prata et al., 2020; Parashar and Hait, 2021; Hiemstra et al., 2021; Gallo Neto et al., 2021). The turtle in this case excreted the mask; however, the physical consequences of debris ingestion in many marine species are under discussion (Kühn et al., 2015). Polypropylene masks are widely used to control corona virus spread. However, plastics potentially contain endocrine-disrupting additives and can sorb hazardous chemicals from seawater (Teuten et al., 2009). In fact, we detected benzotriazole-type UV stabilizers (UVPS, UV329, UV9, UV327, and UV234) in 4 out of 5 brands of face masks we tested, at 1.4 to 848 ng/g (Table 2). This concentration range is similar to those detected in plastic bottle caps, shopping bags, and food packaging (Sakuragi et al., 2021). Estrogenic activity of UVPS and UV329 was recently reported (Sakuragi et al., 2021), and aryl-hydrocarbon-receptor ligand activity of UV9 was reported (Nagayoshi et al., 2015). Thus, exposure of marine organisms which ingest PPE wastes to the chemicals and the consequent endocrine-disruption are of further concern. It is therefore urgently needed to study the ecotoxicological consequences of the ingestion of waste PPE by marine organisms and physical injuries. As a precautionary action, it is necessary to establish appropriate waste management systems to stop the entry of PPE into the environment, and the use of safer additives to PPE (Takada et al., 2022).

Table 2
Concentrations (ng/g) of benzotriazole-type UV stabilizers in polypropylene face masks.

	Blank[a]	Polypropylene face mask samples				
		A	B	C	D	E
UVP	22	26	26	33	28	48
UVPS	0.3	n.d.[b]	n.d.	3.1	n.d.	1.4
UV329	9	17	1	19	14	848
UV9	4	12	n.d.	11	10	8
UV320	0.1	3.0	n.d.	n.d.	n.d.	n.d.
UV350	0.5	n.d.	n.d.	n.d.	n.d.	n.d.
UV326	59	56	42	60	66	61
UV327	0.8	n.d.	n.d.	n.d.	11.2	n.d.
UV328	13	12	12	15	14	12
UV234	2	n.d.	n.d.	n.d.	26	n.d.

[a]Amounts of detected UV stabilizers divided by average sample weight (0.03 g).
[b]n.d.: no peak detected on the chromatograms.
Gray cells: <LOQ (3 × blank value).

CRediT authorship contribution statement

Takuya Fukuoka: Conceptualization, Formal analysis, Investigation, Resources, Writing - original draft, Writing - review & editing, Visualization, Funding acquisition. **Fumiki Sakane**: Methodology, Validation, Formal analysis, Writing - review & editing. **Chihiro Kinoshita**: Conceptualization, Investigation, Resources, Writing - review & editing. **Hideshige Takada**: Methodology, Validation, Formal analysis, Resources, Writing - review & editing, Funding acquisition, Supervision. **Kaoruko Mizukawa**: Methodology, Validation, Formal analysis, Resources, Writing - review & editing. **Katsufumi Sato**: Resources, Writing - review & editing, Funding acquisition, Supervision, Maintenance of monitoring survey.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

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