Growth pattern and microplastic accumulation of *Anadara* spp. harvested from the eastern waters of North Sumatra Province, Indonesia

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Abstract. *Anadara antiquata* and *Anadara granosa* are important consumption commodities for people in North Sumatra Province, Indonesia. However, information regarding microplastic contamination in these two commodities has never been reported, despite the fact that there is a very significant chance of microplastic accumulation in these two species. This research aims to reveal microplastic contamination in *A. antiquata* and *A. granosa* so that people are more aware of the dangers of plastic waste contaminating consumer goods. This research was conducted in Tanjung Balai, Batu Bara, and Langkat districts, North Sumatra Province, Indonesia. The research method was field observation by collecting 50 samples/species/location and then analyzing them at the Biology Laboratory, Universitas Negeri Medan, Indonesia. The results of the analysis of microplastic prevalence based on location and species showed that *A. antiquata* had values of 88%, 96% and 98% respectively from the locations of Tanjung Balai, Batu Bara and Langkat districts; *A. granosa* has sequential values of 100%, 100%, and 90% from the locations of Tanjung Balai, Batu Bara and Langkat districts respectively. The highest microplastic intensity value in *A. antiquata* reached 6.07 particles ind^{-1} collected from Tanjung Balai District, while for *A. granosa* it reached 3.32 particles ind^{-1} collected in Batu Bara District. The analysis results showed that there were three types of microplastics that contaminated the two *Anadara* species, namely fiber, film and fragments. The results of microplastic analysis based on color showed that seven colors were identified, including black, blue, brown, green, purple, red, and transparent.
Key Words: fiber, film, fragment, intensity, prevalence.

Introduction. North Sumatra Province contributes to clams production in Indonesia. There are two species of clams that are most dominantly caught by fishermen, namely *Anadara antiquata* and *A. granosa* (Susetya et al 2018; Mulya & Jhon 2021). Apart from their economic value, clams also contribute greatly to the economy of fishermen, especially women. Generally, clam catchers are female fishermen, while male fishermen catch fish using boats at the sea. The location where clams are caught relatively close to land makes it easier for female fishermen to access work opportunities to help their husbands, who are also fishermen.

It is recorded that the distribution of *A. antiquata* covers the Indo-Pacific region, Australia and the Eastern of Africa which falls into a tropical climate, while *A. granosa* is distributed only in the Indo-Pacific region (Sealifebase 2024). These two species of clams live in estuary waters, bays and mangrove areas with muddy sand substrates and salinity that is not too high at a depth of 0-25 m. *Anadara* species are classified as sessile organisms whose lives depend on the availability of zooplankton, phytoplankton and organic material (Buhadi et al 2013; Yurimoto et al 2021). The *Anadara* species are included in the suspension feeders group, where to obtain food suspended in water (zooplankton, phytoplankton and organic material) is done by filtering the water (Rosa et al 2018). Therefore, clams can potentially pose a danger to those who consume them, because if clams live in polluted waters, the clams meat quickly accumulates toxic substances (Venugopal & Gopakumar 2017).

Microplastics are pollutants that pollute water areas, which every year increases due to the increasing use of plastic (Laskar & Kumar 2019). Mechanical and chemical activities have destroyed whole-size plastic waste into small fragments or microplastics (Jemec et al 2016; Zhou et al 2023). This mechanical activity can occur due to impact and friction so that the plastic is fragmented into pieces (Dehaut et al 2019). Chemical activity occurs due to chemicals, temperature, pH, salinity and minerals which cause plastic to weather so that it easily breaks down and becomes flakes in the form of microplastics (Kumar et al 2024).

The feeding behavior of the *Anadara* species is one of the triggers for the entry of microplastics into their body (Ta et al 2022). Microplastics that accumulate in *Anadara* species are immunotoxic and thus affect the physiology of the organism (Tang et al 2020). The impact of microplastics on humans due to consuming contaminated *Anadara* species includes cytotoxicity, immune response, oxidative stress, and genotoxicity (Yee et al 2021; Danopoulos et al 2022). Therefore, it is important to carry out microplastic analysis on the two *Anadara* species in order to reveal the level of accumulation and its relationship to food health. The analysis of the relationship between length and weight aims to determine the growth pattern of *Anadara* species collected in three different places in North Sumatra, Indonesia.

Material and Method. Clam samples were collected in Tanjung Balai, Batu Bara and Langkat districts (Figure 1) from May 2023 to January 2024. The samples that were collected were then put in styrofoam boxes and transported to the Biology Laboratory, Universitas Negeri Medan, Indonesia.

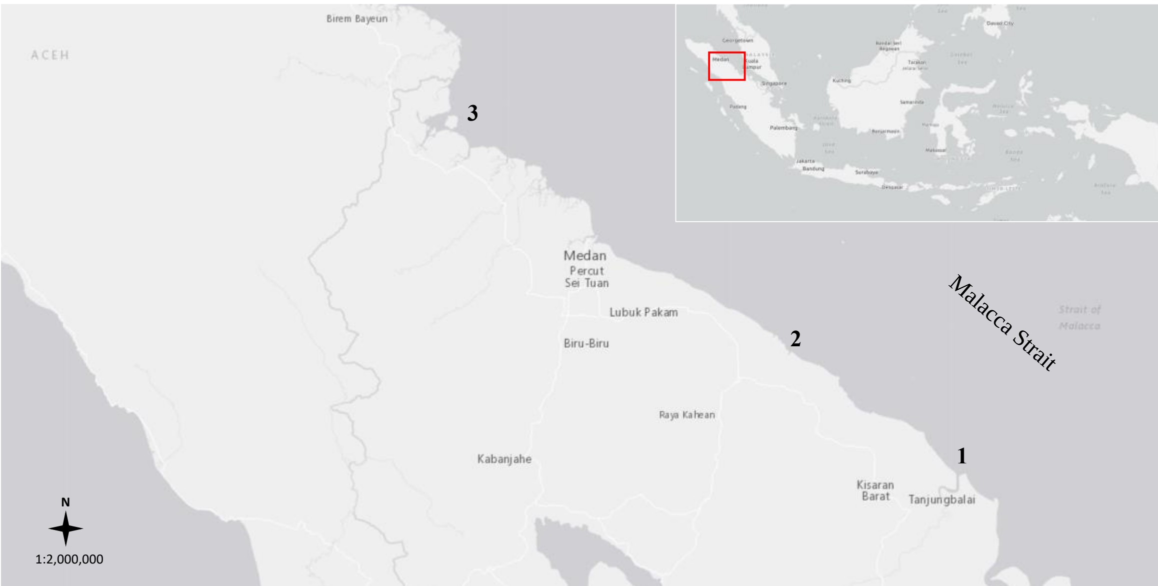

Figure 1. Map of research location: (1) Tanjung Balai District (coordinate points 3°02'22"N 99°52'03"E), (2) Batu Bara District (coordinate points 3°25'21"N 99°19'45"E), and (3) Langkat District (coordinate points 4°08'50"N 98°11'59"E).

A total of 50 samples per species were collected from each research location (Kasmini & Batubara 2023). Shell samples were weighed using a digital scale (error 0.01 g) and length measured using a digital caliper (error 0.01 mm). After weighing, the clam body was separated from the shell using a knife. A 10% KOH solution was prepared in a 100 mL sample bottle to soak the clam meat. The sample bottle was then incubated at 60°C for 24 hours so that all organic material dissolved evenly. The sample was then filtered using Whatman filter paper no. 42 and then incubated until dry. The dried Whatman paper was then placed on a Petri dish. Microplastic observations were carried out using binocular and stereo microscopes.

Length-weight relationship analysis was done using linear allometric model (LAM) using the formula (Batubara et al 2019):

$$W = a.L^b$$

where: W = body weight (g), L = total length (mm), a and b = constants.

The microplastics that were identified were then grouped by type and color. Microplastic prevalence (prevalence = total sample contaminated by microplastic / total sample x 100) and intensity (intensity = total amount of microplastic / total sample contaminated by microplastic) calculations were conducted based on species, type, location and color. The results of the analysis are then explained descriptively. Data on the length and weight of clams were analyzed using regression to reveal growth patterns and life history of clams (Kasmini & Batubara 2023).

Results and Discussion. The results of the analysis of microplastic prevalence based on location and species showed that *A. antiquata* had values of 88%, 96% and 98% respectively from the locations of Tanjung Balai, Batu Bara and Langkat districts; *A. granosa* has sequential values of 100%, 100%, and 90% from the locations of Tanjung Balai, Batu Bara, and Langkat districts. The highest microplastic intensity value in *A. antiquata* reached 6.07 particles ind^{-1} collected from Tanjung Balai districts, while for *A. granosa* 3.32 particles ind^{-1} collected in Batu Bara district (Table 1).

Table 1

Prevalence and intensity of microplastics based on location and species of *Anadara* spp.

Location	*∑ Ind*	*Anadara antiquata*		*Anadara granosa*	
		Prevalence	*Intensity*	*Prevalence*	*Intensity*
Tanjung Balai	50	88	6.07	100	3.16
Batu Bara	50	96	3.5	100	3.32
Langkat	50	98	2.41	90	2

The analysis results showed that there were three types of microplastics that contaminated the two *Anadara* species, namely fiber, film and fragments (Figure 2).

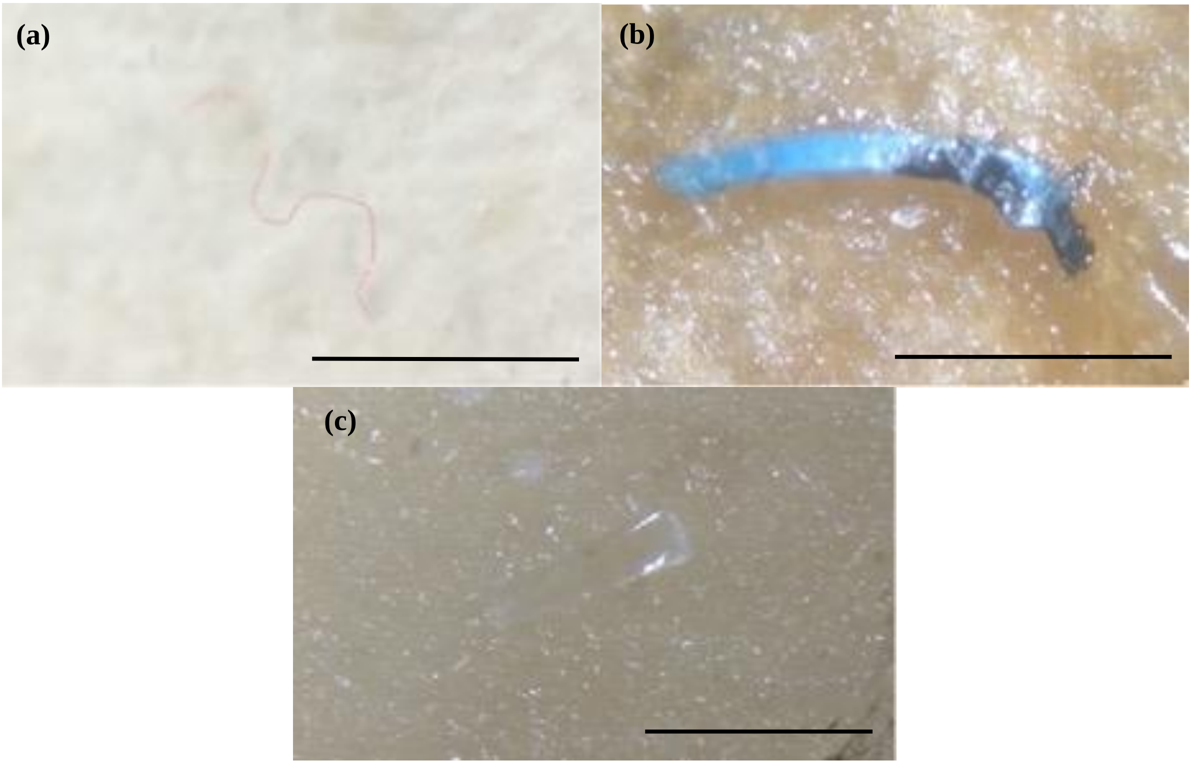

Figure 2. The microplastic types identified in *Anadara* spp. namely (a) fiber, (b) film, and (c) fragment. Scale bar = 0.5 cm.

Prevalence and intensity values based on microplastic type and species show that the two *Anadara* species predominantly accumulate fiber in all study locations. The prevalence value of microplastic fiber in *A. antiquata* was between 85.71 and 97.73%, while in *A. granosa* it was between 95.55 and 100% in the three locations. The prevalence values for film and fragment types of microplastics were lower with a range of 33.33-63.26% and 9.09-43.75% respectively in *A. antiquata*, while in *A. granosa* it was 2-26% and 2.22-8% respectively. The fiber intensity values were between 1.69 and 5.53 particles ind^{-1} for *A. antiquata*, while for *A. granosa* it was between 1.9 and 3.26 particles ind^{-1} at the three research locations. The intensity range of these fibers was higher than films and fragments with a range of 1.12-1.47 particles ind^{-1} and 1-1.14 particles ind^{-1} respectively in *A. antiquata*, and 1-1.38 particles ind^{-1} and 1-1.5 particles ind^{-1} respectively in *A. granosa* (Table 2).

Table 2

Prevalence and intensity value based on type of microplastic in *Anadara* spp.

Species		*Anadara antiquata*			*Anadara granosa*		
Location		I	II	III	I	II	III
∑ ind		50	50	50	50	50	50
Accumulated (ind)		44	48	49	50	50	45
Fiber	Prevalence	97.73	95.83	85.71	96	100	95.55
	Intensity	5.53	2.76	1.69	2.79	3.26	1.9
Film	Prevalence	38.64	33.33	63.26	26	2	17.78
	Intensity	1.47	1.12	1.22	1.38	1	1
Fragment	Prevalence	9.09	43.75	14.28	8	4	2.22
	Intensity	1	1.05	1.14	1.5	1	1

Note: I is Tanjung Balai location, II is Batu Bara location, and III is Langkat location.

The results of microplastic analysis based on color showed that seven colors were identified, including black, blue, brown, green, purple, red, and transparent. In *A. granosa* all seven microplastic colors were identified, whereas in *A. antiquata* only the purple color was nil. The prevalence value of black microplastics dominates compared to other colors with values ranging from 67.34-100% in *A. antiquata* and 82-92% in *A. granosa*. Furthermore, the second highest prevalence value is transparent colored microplastics with values ranging from 59.18-90.91% in *A. antiquata* and 33.33-60% in *A. granosa*. Then followed by red microplastics with values ranging from 29.17-34.69% in *A. antiquata* and 11.11-40% in *A. granosa*. The other colors have a prevalence value of <15% to nil in both *Anadara* species (Table 3).

Table 3

Prevalence and intensity value of microplastics based on color in *Anadara* spp.

Species		*Anadara antiquata*			*Anadara granosa*		
Location		I	II	III	I	II	III
∑ ind		50	50	50	50	50	50
Accumulated (ind)		44	48	49	50	50	45
Blue	Prevalence	6.82	8.33	6.12	-	2	4.44
	Intensity	1	1	1	-	1	1
Brown	Prevalence	2.27	14.58	-	8	6	-
	Intensity	1	1	-	1.5	1	-
Black	Prevalence	100	87.5	67.34	82	92	82.22
	Intensity	3.23	2.28	1.45	2.07	2.17	1.67
Red	Prevalence	29.54	29.17	34.69	20	40	11.11
	Intensity	1.31	1.07	1.12	1	1.25	1.2
Transparent	Prevalence	90.91	60.42	59.18	60	54	33.33
	Intensity	2.6	1.41	1.45	1.9	1.15	1.07
Green	Prevalence	-	12.5	10.2	-	2	6.67
	Intensity	-	1	1	-	1	1
Purple	Prevalence	-	-	-	-	-	2.22
	Intensity	-	-	-	-	-	1

Note: I is Tanjung Balai location, II is Batu Bara location, and III is Langkat location.

The growth pattern is categorized into three, including negative allometric (b < 3), isometric (b = 3), and positive allometic (b > 3).

The results of the length-weight relationship analysis show that *A. antiquata* and *A. granosa* have a negative allometric growth pattern (b < 3) or elongate shape. The b value for *A. antiquata* ranged from 1.33 to 1.52 (Figure 3), while for *A. granosa* it ranged from 0.59 to 1.42 (Figure 4) in the three study locations. A b value < 3 also indicates that both *Anadara* species experienced faster growth in length compared to weight gain.

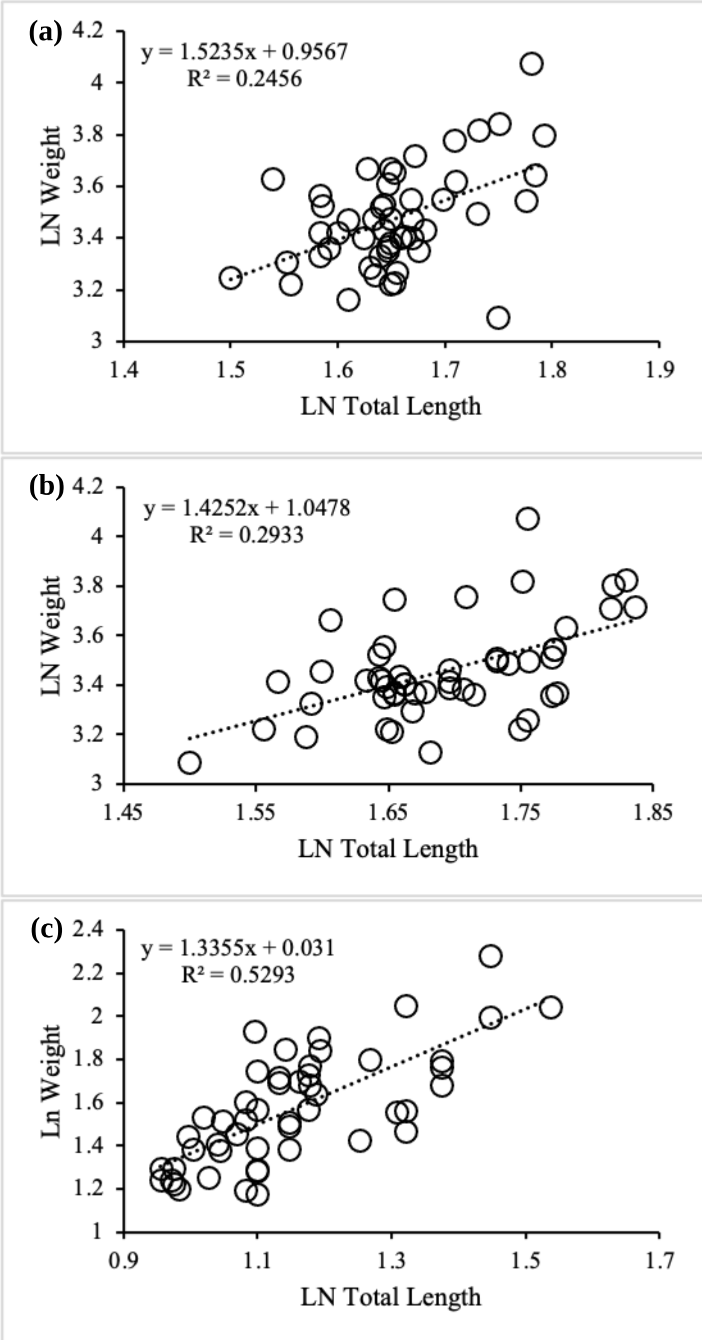

Figure 3. Analysis of the length-weight relationship of *Anadara antiquata* from (a) Tanjung Balai, (b) Batu Bara, and (c) Langkat districts.

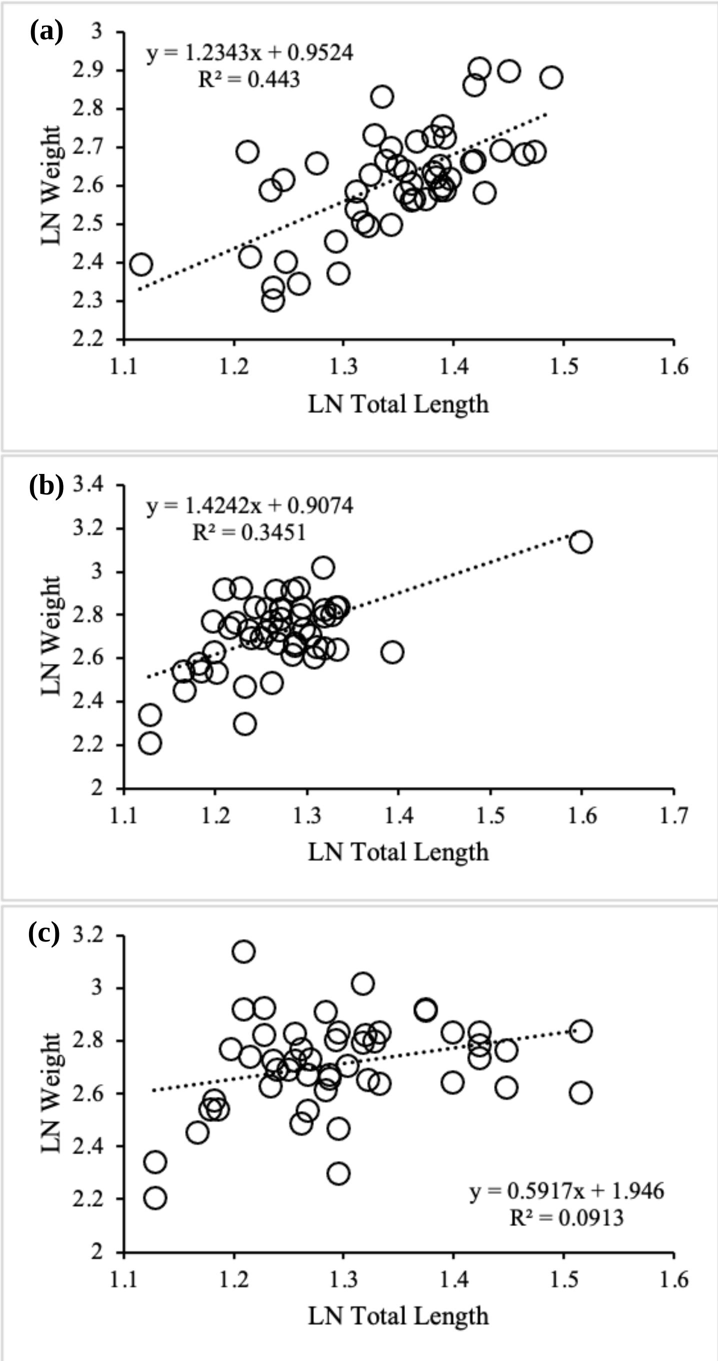

Figure 4. Analysis of the length-weight relationship of *Anadara granosa* from (a) Tanjung Balai, (b) Batu Bara, and (c) Langkat districts.

Microplastic accumulation in *A. antiquata* and *A. granosa* has been successfully revealed at three research locations in North Sumatra Province, Indonesia. A total of 50 samples/species/locations were collected with the highest prevalence value being 100% and the lowest being 88%. These results show that microplastic contamination is very worrying. Apart from having an impact on the physiology of *Anadara* species (Tang et al 2020; Khanjani et al 2023), microplastics also have the potential to impact human health as consumers of *A. antiquata* and *A. granosa* (Basri et al 2021; Montero et al 2023). Human consumption of *Anadara* species polluted with microplastics has several negative effects which include cytotoxicity, immune response, oxidative stress, and genotoxicity (Yee et al 2021; Danopoulos et al 2022).

Microplastics that enter the body of *Anadara* species can trigger disturbances in blood cell composition, haematocytic number, phagocytic activity, and lysozyme activity

(Tang et al 2020). This will have implications for the growth pattern of the *Anadara* species. Based on the analysis of the relationship between length and weight, it shows that both *Anadara* species have a negative allometric growth pattern (b < 3). These results also indicate that both *Anadara* species have an elongated shape. A negative almometric growth pattern indicates that length growth is faster than weight gain (Kasmini & Batubara 2023).

Not only on the east coast of North Sumatra Province, *A. antiquata* has also been contaminated with microplastics on the coast of Tanzania (Mayoma et al 2020). The *A. granosa* species in this study accumulated types of microplastics as fibers, films and fragments, while in the research of Rahmatin et al (2024) on the coast of East Java Province, Indonesia, Goh et al (2021) in Songkla, and Potipat et al (2024) in Chanthaburi, Thailand only identified fibers and fragments. Other research also revealed that *A. granosa* collected from North Borneo, Malaysia was contaminated with microplastics which were dominated by fiber types (Abd Rahman et al 2024). Apart from that, in this study the prevalence of fiber was higher with a value reaching 90-100%, whereas in the study by Rahmatin et al (2024) it was < 80%.

Conclusions. The results of this study reveal the accumulation of microplastic pollutants in *Anadara antiquata* and *Anadara granosa*. Microplastic contamination identified in both species included fibers, films and fragments with black, blue, brown, green, purple, red and transparent colors. Hopefully, information on the accumulation of microplastics in these two species will make the public aware of the impact of plastic waste and be more careful in consuming aquatic organisms.

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Conflict of interest. The authors declare that there is no conflict of interest.

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