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Microplastics Depuration Using Seawater in Asiatic Hard Clams (Meretrix) In The Waters of The Jenelata River, Gowa

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ABSTRACT

Depuration is an effort to reduce/eliminate contamination, including microplastics, using a water circulation system. This study aims to determine the effective depuration time to reduce the microplastic content in Asiatic hard clams (Meretrix). This study used a quantitative approach with an experimental research design and a completely randomized design. There are 450 clams used as an experimental animal where the treatment consisted of four depuration times, namely 1, 2, 3, and 4 days with three repetitions of each treatment, while the control clams were without depuration. Analysis of variance (ANOVA) was used to see the effect of depuration treatment on the microplastic content. If the effect of the treatment was significantly different, then the Post Hoc Test was continued to determine the differences between treatments. The results showed that Asiatic hard clams (Meretrix) obtained from the mouth ofthe Jenelata River, Gowa, were contaminated with microplastics ranging from 0.6 to 8.1 MPs/clam and an average of 3.96 MPs/clam. Depuration time significantly affected the microplastic content in clams' depuration effectiveness. There is a tendency for a longer depuration time to decrease microplastic content in clams. The adequate depuration time to reduce the microplastic content in Asiatic hard clams (Meretrix) was 3 and 4 days. Based on the findings of this study, it is recommended that further research be conducted to explore methods for reducing microplastics using natural materials.

Keywords: Depuration; microplastics; effectiveness; asiatic hard clams; water circulation

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INTRODUCTION

Plastic waste constitutes a significant environmental hazard due to its persistent nature and exponential proliferation. Classified as non-biodegradable, plastic waste presents a challenge for natural decomposition processes and stands as a prominent xenobiotic pollutant—a category encompassing foreign substances capable of infiltrating living organisms [1]. Over time, plastic waste in marine environments undergoes fragmentation into minuscule particles known as microplastics, measuring ≤ 5 mm. These microplastics harbor toxic properties, posing substantial risks upon entering aquatic ecosystems. The presence of microplastics in such environments is primarily attributed to the gradual breakdown of larger plastic fragments through processes like abrasion against sand, wave action, and other mechanical forces [1][2].

Indonesia, boasting the world's second-longest coastline, also holds the dubious distinction of being the second-largest contributor to marine waste globally, trailing only behind China. Projections indicate a further surge in marine waste by 2025, driven entirely by anthropogenic activities. Notably, Indonesia emerges as the foremost contributor to plastic pollution in oceans worldwide, with estimates ranging from 0.48 to 1.29 million metric tons of plastic per year [3]. This alarming figure demonstrates a perpetual escalation, mirroring society's escalating demand for plastic. The substantial accumulation of plastic waste in Indonesian waters poses a dire threat to marine biodiversity. Despite this stark reality, data regarding the prevalence of microplastics in seafood sourced from Indonesian waters remains scarce, underscoring the urgent need for comprehensive research efforts [3][4].

Several studies provide evidence that microplastics accumulate in the marine food chain [5][6]. Scientists have also detected microplastics in human-consumed food items such as salt or bottled drinks, raising concerns about oral exposure through food consumption. Microplastics have been found in numerous environmental and coastal species, including commercially harvested seafood, prompting concerns regarding potential economic impacts and risks associated with food exposure, particularly for coastal communities [6]. However, data on microplastic levels in coastal seafood and their toxicological effects remain scarce, leaving dietary risks largely unexplored. Estimates of microplastic intake through seafood consumption vary widely based on available global data [7][8].

Study results utilizing sediment and water from blood clams revealed that 100% of the samples contained microplastics [9]. Study results involving human fecal samples confirm the inadvertent ingestion of microplastics, which ultimately reach the human intestine [7][10]. One approach to instill consumer confidence in food consumption, particularly clams, involves mitigating or eliminating several hazardous substances, encompassing biological, chemical, or physical hazards [11]. Depuration stands as a crucial step in reducing the presence of various contaminants in clams. Depuration periods vary widely worldwide, ranging from a few hours to several days [8][12].

Clams are biota that have the potential to be contaminated by contaminants such as heavy metals because they are filter feeders. One way to provide a sense of security to consumers regarding food consumption, especially clams, is by eliminating or reducing several dangerous substances, whether from the biological, chemical or physical hazard sectors [13] [14]. In principle, the depuration method is a step in purifying biota such as clams caught in polluted waters and then carrying out a cleaning or depuration process. The aim of this depuration process is to reduce the risk of bacterial contamination and several heavy metals which are dangerous to human health[15][16]. Depuration has the potential to reduce the heavy metal content of Cadmium in clams [17][18].

In addition to heavy metals, depuration holds potential for the elimination of microplastics. Various depuration methods, including recirculation systems, can effectively eliminate or significantly reduce contamination, including microplastics, thus enhancing the safety of clams [17] [19].

Building upon this premise, this study aims to analyze Microplastics Depuration using Seawater in Asiatic Hard Clams (Meretrix) in the Waters of the Jenelata River, Gowa, South Sulawesi.

METHODS

This study employed a quantitative approach with a completely randomized experimental research design [20]. The treatments tested were depuration times: 1, 2, 3, and 4 days, with each treatment replicated three times. The experimental setup consisted of aquariums filled with 60 liters of filtered seawater, aerated, and equipped with a running water system with a flow rate of 3.5 liters per minute. The research was conducted in the waters of the Jenelata River, Gowa, South Sulawesi. Data collection took place from May to November 2023. Sampling of Asiatic hard clams (Meretrix) was conducted to meet the required sample size, with 450 clams drawn based on 5 treatments x 3 replications x 30 clams. A total of 900 clams were prepared as sample supplies. After the depuration period, 10 clams from each treatment were selected for analysis [20] [21]. Examinations and observations were carried out at the Experimental Pond Installation, Research Center for Brackish Water Aquaculture and Fisheries Extension (ITP-BRPBAPPP).

The 900 clams prepared as sample supplies were transported to the Experimental Pond Installation, Research Center for Brackish Water Aquaculture and Fisheries Extension (ITP-BRPBAPPP). These clams were then divided into two groups: the depuration clams group (360 clams) and the control clams group (90 clams). Subsequently, 30 control clams were randomly chosen (10 clams x 3 repetitions) for microplastic content analysis. In the depuration clams group, comprising 360 clams, each group of 30 clams was allocated to 12 aquariums (4 days x 3 repetitions) equipped with a recirculation pump system. Following the depuration process, 10 clams (3 repetitions) from each treatment were analyzed for microplastic content at the Marine Ecotoxicology Laboratory, Faculty of Maritime Affairs and Fisheries, Universitas Hasanuddin, to identify the presence of microplastics. The microplastic samples, representative based on shape and color (8 microplastics each), underwent further testing using the Fourier Transform Infrared (FT-IR) Spectroscopy method.

RESULTS

Geographically, the Jenelata River is a tributary of the Jeneberang River in Parangloe, Gowa, South Sulawesi. This river is situated in the Moncongloe Village area, Manuju. Specifically, it is positioned at 5°17'24.02"S latitude and 119°36'-119°34'46.75"E longitude, spanning a length of 40 kilometers.

Table 1. Morphometric Means of Asiatic Hard Clams (Meretrix) in the Jenelata River, Gowa, South Sulawesi

Value	Morphometric of Asiatic Hard Clams (Meretrix)			
	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)
Minimum	5.5	3.9	3.2	4.9
Maximum	6.5	5.2	3.9	13.9
Mean (Avg.)	5.75	4.38	3.41	10.5
SD	0.29	0.25	0.18	2.0

Information: SD (±) indicates the standard deviation. A lower standard deviation value indicates closer proximity to the mean, whereas a higher standard deviation value indicates a broader range of data deviation.

Based on Table 1, it is known that the Asian hard clams (Meretrix) in the Jenelata River, Gowa, after being measured, have different lengths, widths and heights.

Table 2. Number and Size of Microplastics in Asiatic Hard Clams (Meretrix) (30 clams) in the Jenelata River, Gowa, South Sulawesi

Value	Number of MPs/Clams	MP size (mm)
Minimum	1	0.130
Maximum	20	4,912
Mean (Avg.)	8.2	1,119
SD	5.8	1,109

Information: SD (±) indicates the standard deviation. A lower standard deviation value indicates closer proximity to the mean, whereas a higher standard deviation value indicates a broader range of data deviation.

Based on Table 2, it is evident that all 30 Asiatic hard clams (Meretrix) in the Jenelata River, Gowa, which were analyzed (examined), contained microplastics.

Film-shaped microplastics are longer than other shapes, while the shortest microplastics are fragment-shaped microplastics (Table 3). Based on Table 3, the Size of microplastic shapes, namely, fragment, fiber, film, and monofilament, the average is 0.65, 097, 2.67, and 1.20, respectively.

Table 3. Size of Microplastics (mm) by Shape

Value	Microplastic Shape			
	Fragment	Fiber	Film	Monofilament
Minimum	0.15	0.25	0.60	0.27
Maximum	2.85	3.67	4.79	2.79
Average	0.65	0.97	2.67	1.20
SD	0.39	0.69	1.44	1.38

Table 4 indicates that clams without depuration (control) were found to contain microplastics with a mean amount of 8.2 MPs/clam and a mean size of 1.11 mm. In contrast, clams undergoing depuration exhibited varying levels of microplastics.

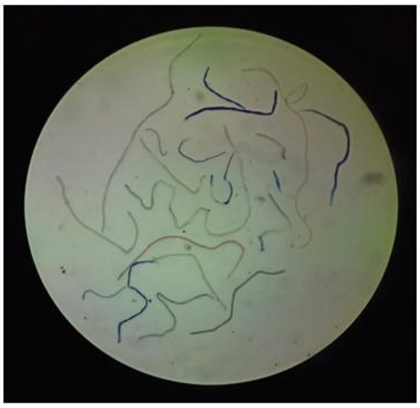

Figure 1.
Microplastics in the Control Figure

Figure 2.
Microplastics Depuration

Table 4. Number and Size of Microplastics in Clam Meat during Depuration Treatment and Time (Min-Max; Mean ± SD)

Value	Depuration Time				
	Control	1	2	3	4
Microplastic Content (MPs/clams)	6.8-9.3 8.2±1.4	1.5-9.5 4.4±4.6	1.8-9.1 6.2±4.0	0.4-1.2 0.8±0.4	0.1-1.2 0.7±0.6
Microplastic Size (mm)	0.8-1.3 1.11±0.2	1.4-2.2 1.7±0.5	1.3-1.8 1.6±0.4	0.6-1.6 0.9±0.6	0.2-1.7 1.2±0.9

Information: SD (±) indicates the standard deviation. A lower standard deviation value indicates closer proximity to the mean, whereas a higher standard deviation value indicates a broader range of data deviation.

Specifically, clams undergoing depuration for 1 day contained a mean of 4.4 MPs/clam with a mean size of 1.7 mm; clams undergoing depuration for 2 days contained a mean of 6.2 MPs/clam with a mean size of 1.6 mm; clams undergoing depuration for 3 days contained a mean of 0.8 MPs/clam with a mean size of 0.9 mm; and clams undergoing depuration for 4 days contained a mean of 0.7 MPs/clam with a mean size of 1.2 mm.

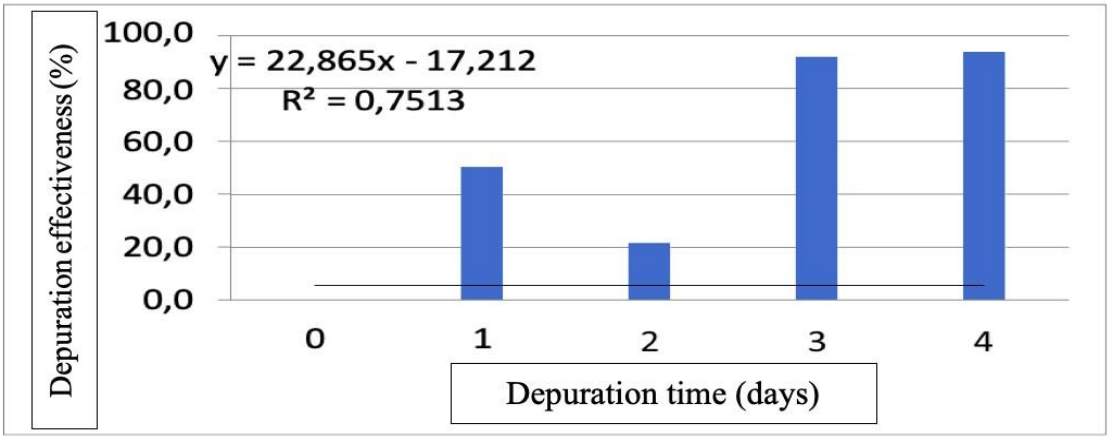

Figure 3. Effectiveness of Microplastics Depuration in Asiatic Hard Clams (Meretrix)

Regarding the effectiveness of depuration time shown in Figure 3, the treatments of 0 day, 1 day depuration, and 2 days depuration did not show a significant difference in depuration effectiveness.

Similarly, there was no significant difference in depuration effectiveness between 3 days depuration and 4 days depuration. However, a significant difference in depuration effectiveness is evident when comparing the percentage of microplastics remaining between the treatments of 0 day (46.913%) and 4 days depuration (93.004%).

Table 5. Depuration Water Quality

Total	Treatment/Depuration (Days)				Optimal Value
	1	2	3	4	
	(Min-Max Mean±SD	(Min-Max Mean±SD	(Min-Max Mean±SD	(Min-Max Mean±SD	
Temperature (^{0}C)	25.5-26.30 25.79±0.43	25.5-26.3 25.79±0.43	24.9-26.50 25.69±0.57	24.8-26.4 25.70±0.55	28-32
Salinity (ppt)	35.39-35.64 35.54±0.12	35.38-35.62 35.46±0.10	35.35-35.63 35.46±0.09	35.37-36.62 35.39±0.33	<30
pH	8.20-8.87 8.56±0.36	8.22-9.04 8.76±0.33	7.74-9.07 8.71±0.33	7.92-9.01 8.52±0.44	7-8.6
Dissolved oxygen (mg/ltr)	4.64-5.40 5.10±0.28	4.70-5.29 5.11±0.21	4.49-5.18 4.94±0.21	4.63-5.37 5.06±0.23	>5

Information: SD (±) indicates the standard deviation. A lower standard deviation value indicates closer proximity to the mean, whereas a higher standard deviation value indicates a broader range of data deviation.

The measurement of depuration water quality was conducted twice a day, in the morning and evening. Based on Table 5, the results indicate that the temperature measurements during the depuration process of Asiatic hard clams (Meretrix) were lower than the Quality Standards Decree of the Minister of the Environment No. 51 of 2004 concerning Sea Water Quality Standards for Marine Biota. Specifically, the temperature measurements ranged from 24.6°C to 26.4°C, while the Quality Standards stipulate a range of 28°C to 32°C.

The salinity of the water utilized for depuration ranged from 35.37 to 36.62 ppt, with the pH of the water ranging from 7.74 to 9.07. The highest acidity level was recorded in the water from the treatment of 3 days depuration. Dissolved oxygen levels in each treatment ranged between 4.49 and 5.40 mg/l, which closely aligns with the Quality Standards of dissolved oxygen of >5 mg/l.

DISCUSSION

Asiatic Hard Clams (Meretrix) collected from the waters of the Jenelata River in Gowa were found to be 100% contaminated with microplastics. These clams exhibited lengths ranging from 5.5 to 6.5 cm (with a mean of 5.75 cm ± 0.9 cm), widths ranging from 3.9 to 5.2 cm (with a mean of 4.38 cm ± 0.25 cm), thicknesses ranging from 3.2 to 3.9 cm (with a mean of 3.41 cm ± 0.18 cm), and weights ranging from 4.9 to 13.9 g (with a mean of 10.5 g ± 2.0 g). However, there was no discernible relationship between clam morphometrics (length, width, thickness, weight) and microplastic content in these clams. This observation is consistent with the findings of Birnstiel et al. (2019), who reported no discernible relationship between clam size and microplastic concentration [20].

The mean microplastic content in Asiatic hard clams (Meretrix) ranged from 0.6 to 8.1 MPs/clam. As the depuration process prolonged, the percentage of clams contaminated with microplastics decreased. However, the depuration effectiveness at 1 day and 2 days did not significantly differ from the treatment without depuration (control). Interestingly, the results indicated that the contamination levels after 2 days depuration was higher compared to 1 day of depuration. This increase in microplastic contamination is attributed to the clam adaptation process, known as the lag phase. This observation aligns with the findings of C. Hannon (2023), who suggested that significant growth in clams at the beginning of treatment is indicative of an ongoing adaptation phase. However, after completing the adaptation phase (lag phase), significant differences in depuration effectiveness become apparent, particularly after 3 days and 4 days depuration, showing a significant improvement compared to the treatment without depuration (control), 1 day depuration, and 2 days depuration [22].

The presence of microplastics in Asiatic hard clams (Meretrix) in the waters of the Janelata River can be attributed to the sampling area, which encompasses the estuary of the river flow—a region affected by the activities of local residents and fish farms. Additionally, the prevalence of scattered plastic waste such as beverage packaging, pipes, ropes, plastic bags, food wrappers, sacks, and others, contributes to the contamination. During the depuration process, clams are not fed to prevent contamination. As described by Un Nutrion (2021), the filtration of food by clams occurs when they open their shells [23], with the clams closing in response to threats. This filtering process also facilitates the absorption of pollutants. Clams utilize their adductor muscle structure to regulate shell opening and closing during filter feeding. Similarly, the ligament connecting the two shells responds to pressure conditions, facilitating shell movement [6] [24].

When treating clams with depuration, it is crucial to pay attention to the feeding mechanism, as the process of microplastic entering the clams' bodies could originate from the food they consume [25]. Depuration can significantly reduce contaminants in clams compared to untreated clams (control). Living clams excrete contaminants, and these excretions, which contain contaminants, are subsequently removed through the depuration process, where the water is purified by continuous circulation facilitated by a pump system [26] [27] [28].

In the Jenelata River, various shapes of microplastics were identified, including fibers, fragments, films, and monofilaments. Fragments were the most common shape of microplastic found in control clams, whereas during the depuration process, films and fibers were predominant, particularly after 4 days depuration. The prevalent microplastic type in both control and depurated clams was blue fibers. Differences in microplastic shapes can help identify their sources. The abundance of microplastic fragments observed during the depuration process suggests the presence of thick plastic waste, such as bottles (beverage packaging), plastic bags, and pieces of PVC pipes, in the vicinity of the Jenelata River.

Microplastic films detected in the Jenelata River likely originate from plastic bags and food wrappers, while fibers are likely sourced from seaweed cultivation ropes, ship ropes, and fishing nets commonly used by fishermen in the area. These findings are consistent with a study conducted by Winesti Tubagus et al. (2020) in the Seribu Islands, Jakarta, which revealed the presence of microplastic fibers, films, and fragments in clams (Gafrarium tumldum) [29].

As a result of the depuration process in the four treatments, the quantity of microplastic films did not change significantly, unlike microplastic fibers, fragments, and monofilaments, which exhibited reductions in quantity as the duration of depuration increased. The water quality utilized during depuration is also a crucial factor influencing the success rate of depuration and could potentially lead to clam mortality. Therefore, the depuration water should be monitored at least twice during the depuration process to ensure its quality.

CONCLUSIONS AND RECOMMENDATIONS

The Asiatic hard clams (Meretrix) in the waters of the Jenelata River, Gowa, were found to be contaminated with microplastics in various shapes, including fragments, fibers, films, and monofilaments. The microplastic content in clams can be effectively reduced through depuration using flowing seawater for a duration of 4 days, achieving an effectiveness rate of 93%. Based on the findings of this study, it is recommended that further study be conducted to explore methods for reducing microplastics using natural materials.

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