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Analysis of The Absorption Capabilities of The Heavy Metal Mercury (Hg) in Mangrove Crab (*Scylla serrata*), Mangrove Snail (*Telescopium telescopium*) and Mangrove Clams (*Polymesoda erosa*)

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Abstract

Mercury is a neurotoxic heavy metal with high bioaccumulation ability in aquatic biota, such as mangrove crabs (*Scylla serrata*), mangrove snails (*Telescopium telescopium*), and mangrove mussels (*Polymesoda erosa*), which are widely consumed by humans, and used as bioindicators of pollution. This study aimed to analyze the effect of mercury solution concentration and species differences on mercury absorption in the three biota. The method used was experimental treatment with mercury concentrations of 1 ppm, 5 ppm, 10 ppm, and control. Samples were analyzed using the *AAS Cold Vapor* method at the IPB Bogor Proling Laboratory. Data were analyzed descriptively and inferentially using two-way Anova with an α level of 0.05, followed by the Duncan Test if the hypothesis was accepted. Research data will be processed using SPSS 26.0 software. The results showed that mercury concentration and species differences influenced the ability to absorb mercury. Mangrove clams had the highest mercury accumulation compared to mangrove snails and mangrove crabs, especially in the 5 ppm and 10 ppm treatments. The highest mercury exposure occurred on the second day of observation.

Keywords: Heavy Metal Mercury (Hg), Mangrove Crab (Scylla serrata), Mangrove Snail (Telescopium telescopium), Mangrove Clams (Polymesoda erosa)

INTRODUCTION

Mercury, denoted by the chemical symbol Hg, is one of the most dangerous heavy metals that presents a serious global threat to living organisms (Jafari & Cheraghi, 2014). Mercury contamination impacts a wide range of environmental systems, even at low concentrations (Attwaters, 2023). Mercury affects both humans and other organisms because it is neurotoxic by causing adverse health effects (Salatutin et al., 2015). Exposure to high concentrations of mercury can cause permanent brain damage and kidney dysfunction (Chen & Shiyuan, 2022). According to the Agency for Toxic Substances and Disease Registry, mercury is ranked third on the priority list of hazardous substances, indicating its very significant threat level (Danouche et al., 2021).

Mercury heavy metal pollution is one of the significant environmental problems caused by human activities such as mining, industry, and domestic waste. Heavy metals have high bioaccumulation properties, so they can accumulate in the bodies of organisms living in aquatic ecosystems, including mangrove crabs (*Scylla serrata*), mangrove snails (*Telescopium telescopium*), and mangrove mussels (*Polymesoda erosa*) which are widely used by the community as a food source (Elvira et al., 2016; Noviani et al., 2020). These organisms are often used as bioindicators of pollution because they can absorb heavy metals from

their environment through bioaccumulation and biomagnification processes.

Previous research showed the accumulation of mercury in the three types of biota, namely mangrove crabs in the waters of Kayeli Bay, Buru Regency (Irsan et al., 2023) mangrove crabs in the waters of Cengkok beach, Banten Bay (Noviani et al., 2020), mangrove snails in Kayeli Bay, Buru Regency (Irsan et al., 2023), mangrove mangrove snails in Kao Bay, North Halmahera (Samman, 2014), mangrove mussels in Kayeli Bay, Buru Regency (Irsan. et al., 2020) and mangrove mussels in Butuan Bay, Philippines (Elvira et al., 2016). However, studies related to the specific ability of biota to absorb mercury through experimental approaches in the laboratory are still minimal. On the other hand, research integrating bioremediation approaches using estuary biota as mercury sorbents has also become the focus of scientific attention in recent years. A deeper understanding of mercury uptake patterns at the laboratory scale can provide more concrete data for ecosystem-based pollution mitigation strategies.

This study aims to explore the mercury uptake ability of mangrove crabs, mangrove snails, and mangrove mussels through a laboratory experiment approach. This research comprehensively studies of mercury accumulation patterns in these three biota under controlled conditions. The results are expected to contribute to the development of local biota-based bioremediation methods, which is an environmentally friendly approach to addressing mercury pollution in coastal aquatic ecosystems.

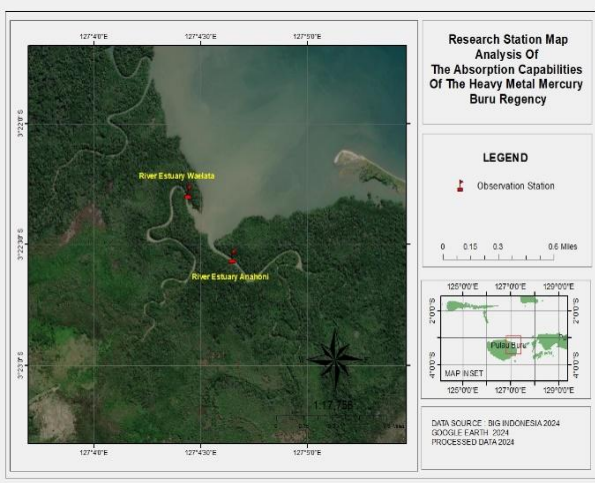


Figure 1. Sampling location (mangrove crab, mangrove snail and mangrove clam)

Based on the background description, the objectives of this study are:

1. Analyze whether there is an effect of mercury solution concentration on the ability of heavy metal mercury (Hg) uptake of mangrove crabs (*Scylla serrata*), mangrove snails (*Telescopium telescopium*) and mangrove mussels (*Polymesoda erosa*).
2. Analyze whether species differences affect the heavy metal mercury (Hg) uptake ability of mud crabs (*Scylla serrata*), mud snails (*Telescopium telescopium*) and mud clams (*Polymesoda erosa*).
3. Analyze whether the combination of mercury solution concentration and species differences affect the heavy metal mercury (Hg) uptake ability of mud crab (*Scylla serrata*), mud snail (*Telescopium telescopium*) and mud clam (*Polymesoda erosa*).

METHODOLOGY

Tools and Materials

The tools and materials used in this study consist of: a glass reactor, sample box, tray, knife, Shall Lab Oven, Cold Vapor Atomic Absorption Spectrophotometry (AAS) set of tools, heavy metal mercury, 5 kg sugar paper, research samples (mangrove crab, mangrove snail and mangrove clam), seawater, H_2SO_4, distilled water, standard solution, HNO_3, H_2O_2, HCl, 0.45 µm filter paper.

Methods

The method used in this research is experimental. The research procedure is divided into research experiment design and preparation of rearing media, sampling, testing the initial concentration of mercury in seawater and research samples, treatment of rearing media exposure with mercury solution and analysis of mercury concentration.

1. **Experimental Design and Preparation of Maintenance Media**
   This study used a completely randomized design (CRD) experimental design. For sample maintenance media, reactors made of square glass with a thickness of 5 mm and a size of 50 x 40 x 30 cm were used. This study, 4 reactors were used (each treatment consisted of 1 reactor).
2. **Sample Collection**
   Samples were collected at the Waelata and Anahoni Rivers estuaries in Buru Regency (Figure 1). The total number of samples included 8 mangrove crabs, each weighing between 400-500 g; 20 mangrove snails with individual weights ranging from 70-110 g; and 20 mangrove clams, each weighing between 70-110 g.

3. **Initial Mercury Concentration Test in Seawater and Research Samples**
   Before treatment, mercury concentration tests were conducted on seawater samples and research samples. As much as 220 ml of seawater was taken from each treatment, while for biota samples, 1 mangrove crab and 3 each of mangrove snails and mussels were taken. Biota samples were also taken from the meat for mercury analysis.
4. **Exposure Treatment with Mercury Solution**
   Before the treatment, all three types of samples were acclimatized for 24 hours. The treatments consisted of three different mercury concentrations and one control, each replicated twice (Musa et al., 2020). The exposures were carried out for two different durations: one day and two days, as outlined below:
   Control (K) : Seawater without added mercury (K1 and K2)
   Treatment A : Seawater with added mercury concentration of 1 ppm (A1 and A2)
   Treatment B : Seawater with added mercury concentration of 5 ppm (B1 and B2)
   Treatment C : Seawater with added mercury concentration of 10 ppm (C1 and C2
5. **Mercury Concentration Analysis**
   The samples taken for mercury analysis are the meat parts. In addition, the concentration of mercury in seawater in the sample-rearing media in all treatments will also be analyzed. The research samples will be analyzed at the Proling Laboratory of IPB Bogor. The laboratory research procedures are as follows:

a. Seawater Sample

Seawater samples were collected in 220 mL quantities using pre-sterilized black bottles. To preserve the samples, 0.25 mL of H_2SO_4 was added as a preservative. The samples were then stored in a cool box before being sent to the laboratory for heavy metal analysis (Irsan., 2015).

b. Mangrove Crab, Mangrove Snail, and Mangrove Clam Samples

1. **Cleaning and Drying of Samples**
   The mangrove crab, mangrove snail, and mangrove clam samples intended for mercury analysis were thoroughly cleaned with distilled water (aquades). The samples were then cut into smaller pieces. Following this, the samples were dried in an oven at 40ºC for 48 hours (Male et al., 2014).
2. **Preparation of Standard Solution and Sample Preparation**
   The preparation of standard solutions follows the (Badan Standarisasi Nasional (SNI), 2016) as outlined below:
   a. Primary Standard Solution: 1000 mg/L
   b. First Secondary Standard Solution (i): 10 mg/L, Pipette 1 mL of the primary standard solution (1000 mg/L) into a 100 mL volumetric flask, then dilute with a 20% HNO3-H2SO4 solution (v/v).
   c. Second Secondary Standard Solution (ii): 1 mg/L, Pipette 5 mL of the first secondary solution (i) into a 50 mL volumetric flask and dilute with 20% HNO3- H_2SO_4 solution. Third Secondary Standard Solution (0.1 mg/L): Pipette 5 mL of the second secondary solution (ii) into a 50 mL volumetric flask and dilute with 20% HNO3- H_2SO_4 solution.
   d. Working Standard Solution (1 µg/L, 5 µg/L, 10 µg/L, 15 µg/L, and 20 µg/L) Pipette 0.5 mL, 1 mL, 5 mL, 7.5 mL, and 10 mL of the third secondary solution (iii) into a 10 mL volumetric flask and dilute with 20% HNO3- H_2SO_4 solution.
   e. These working standard solutions are prepared at the time of analysis.

   Sample Preparation Procedure (Badan Standarisasi Nasional (SNI), 2016):
   a. Grind the samples into fine particles.
   b. Weigh 2 grams of each type of marine biota sample or 6 grams for replicates.
   c. Label each sample and add 5 mL of HNO3.
   d. Let it sit overnight.
   e. Heat again at 120°C for 1 hour on a hot plate. Add 1 mL of Hydrogen Peroxide (H_2O_2).
   f. Heat again at 120°C for 1 hour on a hot plate until the solution becomes clear. Allow to cool.
   g. Add 1 mL of Hydrochloric Acid (HCl) and transfer the solution into a 50 mL volumetric flask. Then, dilute with distilled water (aqua demineralized) up to the mark.
   h. Filter using a 0.45 µm filter paper. The sample is now ready to be analyzed using the Atomic Absorption Spectrophotometry (AAS) Cold Vapor method.

c. Analysis (Determination) of Mercury Heavy Metal Concentration

The determination of mercury heavy metal concentration was carried out using the Atomic Absorption Spectrophotometry (AAS) Cold Vapor method (Irsan. et al., 2020) as follows:

a. The AAS instrument is optimized and calibrated for the cold vapor technique.
b. Sodium borohydride solution is placed into the reduction vessel.
c. Prepare 10-50 mL of the sample or standard solution in a reduction bottle, and insert it into the instrument. Wait for 5 seconds for pre-reaction.
d. Prepare 10-50 mL of the sample or standard in the reduction bottle and place it into the instrument. Then, press START on the software, followed by pressing ENTER. Press the reduction button until absorbance (absorption value) appears on the screen.
e. Once the absorbance value appears, stop pressing the reduction button.
f. Wait 10 seconds to ensure that the vapor has been carried by argon gas before proceeding to the following analysis.

Data Analysis

The data obtained in the study will be analyzed descriptively and inferentially. A descriptive analysis was conducted to describe the results of the analysis of mercury concentration in seawater media and biota samples before and after heavy metal mercury treatment using tables and graphs. At the sometimes inferential analysis was used to test the research hypothesis using the Two-Way ANOVA Test. Before hypothesis testing, the normality requirement test was first carried out with an α level of 0.05 using SPSS 26.0 software. If the results of the analysis show that the Ha hypothesis is accepted and H0 is rejected, the Duncan test will be continued with an α level of 0.05 to see the difference between one treatment and another.

RESULTS AND DISCUSSION

Description of Mercury Heavy Metal Concentration Analysis Results on Samples

The mercury concentration analysis was conducted on both the seawater media and the biota samples before and after mercury heavy metal treatment exposure. Before the treatment, a pre-treatment mercury concentration test was first conducted on the seawater sample used as the media for sample maintenance (Table 1), and on the biota samples, with each type sampled from 3 individuals (Table 2). The determination of mercury heavy metal concentration was carried out using the Atomic Absorption Spectrophotometry (AAS) Cold Vapor method.

Table 1. Pre-Treatment Mercury Concentration Analysis Results in Seawater Samples

Sample Type	Treatment / Sample Type	Mercury Concentration (mg/kg)	Detection Limit (DL) (mg/kg)
Sea water	A00	<0,0001	0,0001
	A01	<0,0001	
	A02	<0,0001	
	A03	<0,0001	

Table 1 shows that the mercury concentration in the seawater used as the medium for maintaining the biota is still below the instrument's detection limit, which is <0.0001 mg/kg.

Table 2. Results of pre-concentration mercury analysis in biota samples

Sample Type	Treatment/ Sample Type	Mercury Concentration (mg/kg)	Max. Limit (mg/kg)	Detection Limit (DL) (mg/kg)
Biota	Mangrove crab (*Scylla serrata)*	3,295	1,0	0,004
	Mangrove snail (*Telescopium telescopium)*	3,702		
	Mangrove clam (*Polymesoda erosa)*	6,947		

The results of the analysis of mercury concentrations in samples of mangrove crab, mangrove conch and mangrove clam biota before mercury exposure treatment listed in Table 2 show that the concentration of mercury found in the three types of samples has a range of 3.295 mg/kg to 6.947 mg/kg. This indicates a significant accumulation of mercury because the concentration of mercury in the three samples is above the maximum limit based on Indonesian National Standard (SNI) No. 7387 of 2009 for special food for heavy metal Hg in shellfish (bilvalve), mollusks and sea cucumbers, shrimp and other crustaceans of 1.0 mg/kg (ppm) (Badan Standarisasi Nasional (BSN), 2009). The accumulation of mercury in the samples is related to the habitat of the samples, where the estuary area of the Waelata River and the Yan River as the sampling location is an area that is heavily affected by heavy metal mercury due to unlicensed gold mining activities in Buru Regency. This is supported by several previous studies that found mercury accumulated in mangrove crabs (*Scylla*

serrata), mangrove snails (*Telescopium telescopium*) and mangrove mussels (*Polymesoda erosa*) (Irsan. et al., 2020; Irsan et al., 2023) in the estuary of the Waelata River and Anahoni River in Buru Regency.

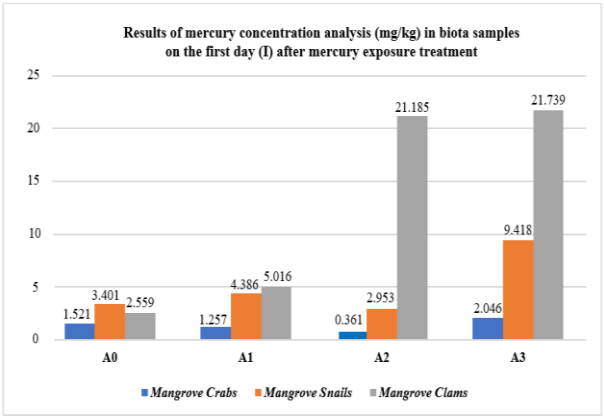
After the pre-test (initial mercury concentration) was conducted on the seawater and biota samples, an experiment was then carried out by exposing the samples to mercury solution treatment (without mercury exposure (A0), 1 ppm concentration (A1), 5 ppm concentration (A2), and 10 ppm concentration (A3) for two days. After the treatment, mercury analysis was performed on the seawater used as the medium for sample cultivation in all treatments on the first and second days (Table 3), as well as on the biota samples (mangrove crab, mangrove snail, and mangrove clam) on the first and second days after treatment (Figure 2).

Table 3. Results of mercury concentration analysis in seawater samples on the first (I) and second (II) days after mercury exposure treatment

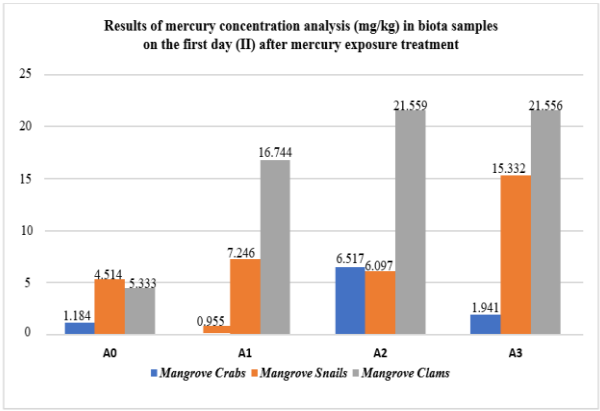
Sample Type	Treatment	Mercury Consentration (mg/kg)	
		Day I	Day II
Seawater	A0	<0,0001	<0,0001
	A1	0,0199	0,0192
	A2	0,0390	0,0164
	A3	0,1493	0,1263

Table 3 showed that A0 (without treatment, control) did not contain mercury metal on both the first and second observation days. This is because A0 served as the control group in the experiment. In contrast, mercury was detected in the other treatments (A1, A2, and A3), as these treatments were exposed to mercury. Furthermore, the highest mercury concentration was found in treatment A3, which had the highest mercury concentration. The mercury concentrations for each treatment during the first (I) and second (II) observations can be seen in Figure 2.

The results of mercury metal analysis in biota samples (mangrove crab, mangrove snail, and mangrove clam) on the first and second days after treatment, as shown in Figure 2, revealed that the mangrove clam species (*Polymesoda erosa*) is the species with the highest accumulation of mercury, both on the first and second observation days, followed by the mangrove snail (*Telescopium telescopium*) and the mangrove crab (*Scylla serrata*), which showed the lowest mercury accumulation. The highest mercury accumulation was also observed on the second day after mercury exposure treatment. The accumulation of heavy metals in living creatures is also known as bioaccumulation Campbell defines heavy metal bioaccumulation chemically as a reaction of the formation to complex compounds between heavy metals and organism cells, which function as ligands. Bioaccumulation is a process in which an organism absorbs and stores heavy metals from the environment and/or food so that the concentration of these substances in the organism's body becomes higher than the concentration of these substances in the surrounding environment (Fakaubun et al., 2020).



(a)



(b)

Figure 2. Results of mercury metal analysis in biota samples (mangrove crab, mangrove snail, and mangrove clam) on the first day (a) and second day (b) after treatment

The differences in mercury accumulation capacity are due to the varying abilities of each species to accumulate metals in their bodies. This is related to various factors, particularly the feeding habits of each species. When considering the feeding method and types of food, the mangrove clam is the biota with the highest mercury accumulation. This is likely due to its filter-feeding behavior, as in this study, mercury was directly applied to the cultivation medium, and no food

was provided to the three biota species after treatment. Consequently, organisms with filter-feeding habits accumulate more mercury in their bodies. This aligns with (Zuykov et al., 2013) who stated that filter-feeding organisms, such as clams, concentrate contaminants from water into their tissues through bioaccumulation. In contrast, biota with different feeding habits, such as the mangrove crab, accumulate less mercury. Pasaribu explained that the mangrove crab primarily feeds on shellfish, shrimp, fish, algae, and mangrove leaves (Irsan et al., 2023) As for the mangrove snail, it accumulates more mercury than the mangrove crab because this species is a detritivore that feeds on fine particles (Haque & Choudhury, 2015; Willan, 2013).

Mercury concentrations on the second observation day (II) were higher than on the first (I). However, there were some exceptions, such as mercury concentrations in mud crabs in treatments A0 and A1. This is related to various factors, including the gradual accumulation of mercury, differences in absorption and distribution rates, and exposure time.

Organisms such as mangrove crabs, mangrove snails and mangrove mussels can absorb mercury from their environment through bioaccumulation. Over time, mercury concentration in organisms' bodies tends to increase because mercury is not easily excreted from their bodies (Clarkson & Magos, 2006). Day II may represent sufficient time for mercury to reach the highest concentration in the organism's body, especially for treatments with high mercury concentrations, such as A2 and A3 in mangrove mussels. In addition, the slow metabolism in these organisms may cause a longer time for mercury to be evenly distributed in the body tissues (Scheuhammer et al., 2007).

In mangrove crabs, mercury concentrations on day II were not always higher than on day I, especially in treatments A0 and A1, which showed lower values on day II. This may occur because the crabs may have particular physiological mechanisms that limit mercury accumulation or due to mercury loss through excretion or molting. For mangrove snails, the mercury concentration on day II increased significantly in almost all treatments; for example, in treatment A3, the value increased from 9.418 mg/kg (day I) to 15.332 mg/kg (day II). Mangrove snails are known to have high bioaccumulation rates due to their habit of feeding on sediment particles containing mercury (Lavoie et al., 2013). he highest mercury concentration was found in the mangrove conch, especially in treatments A2 and A3. In fact, on day II, the mercury concentration was stable, such as in treatment A3, with a value of 21.5 mg/kg. Mussels have a high filtration ability, so they are very susceptible to mercury buildup from water and sediment (Boening, 2000).

Normality Test

Before testing the hypothesis, the normality requirement test was carried out with an α level of 0.05. The Normality testing is conducted to determine whether the data from the research follows a normal distribution. This test is performed using the non-parametric Kolmogorov-Smirnov statistical test. Normality testing is a prerequisite for conducting hypothesis testing. The Shapiro-Wilk test will be used in this study since the sample size is small (below 50). The test will be performed with the help of SPSS version 26.0, and the significance level used is 0.05. To determine whether the data follows a normal distribution, the SPSS output will be interpreted as follows:

1. If the output value in the *sig.* column of the SPSS test result is greater than the significance level ($p > 0.05$), the data is considered normally distributed.
2. If the output value in the *sig.* column of the SPSS test result is less than or equal to the significance level ($p \leq 0.05$), the data is considered not normally distributed.

The results of the normality test analysis with an α level of 0.05, are shown in Table 4.

Table 4. Shapiro-Wilk Normality Test Results with SPSS 26.0 at α 0.05

	Mercury Concentration (Hg)	Shapiro-Wilk		
		Statistic	df	Sig.
Mercury Accumulation (Hg)	Concentration A0	.948	6	.726
	Concentration A1	.839	6	.128
	Concentration A2	.824	6	.095
	Concentration A3	.866	6	.211

Table 4 shows that the output values in the Sig. column from the SPSS test is greater than the significance level ($p > 0.05$), so it can be concluded that the research data is usually distributed. Therefore, the analysis can proceed with hypothesis testing using Two-Way ANOVA at α 0.05. ANOVA is used to determine the effect of the treatments and species and the combination of both on mercury accumulation in the samples.

Hypothesis Testing

In this research, 3 types of hypotheses will be tested, namely:

1. Hypothesis 1:
   Ha: There is an effect of mercury solution concentration on the mercury absorption capacity (Hg) in Mangrove Crabs (*Scylla serrata*), Mangrove Snails (*Telescopium telescopium*), and Mangrove Clams (*Polymeoda erosa*).
   H0: There is no effect of mercury solution concentration on the mercury absorption capacity (Hg) in Mangrove Crabs (*Scylla serrata*), Mangrove Snailss (*Telescopium telescopium*), and Mangrove Clams (*Polymeoda erosa*).
2. Hypothesis 2:
   Ha: The species differences affect the mercury absorption capacity (Hg) in Mangrove Crabs (*Scylla serrata*), Mangrove Snails (*Telescopium telescopium*), and Mangrove Clams (*Polymeoda erosa*).
   H0: The species differences do not affect the mercury absorption capacity (Hg) in the Mangrove Crabs (*Scylla serrata*), Mangrove Snails (*Telescopium telescopium*), and Mangrove Clams (*Polymeoda erosa*).
3. Hypothesis 3:
   Ha: The combination of mercury solution concentration and species differences affects the mercury absorption capacity (Hg) in Mangrove Crabs (*Scylla serrata*), Mangrove Snails (*Telescopium telescopium*), and Mangrove Clams (*Polymeoda erosa*).
   H0: The combination of mercury solution concentration and species differences does not affect the mercury absorption capacity (Hg) in Mangrove Crabs (*Scylla serrata*), Mangrove Snails (*Telescopium telescopium*), and Mangrove Clams (*Polymeoda erosa*).

The decision-making criteria for hypothesis testing are as follows:

1. If the significance value (Sig.) < 0.05, then Ha is accepted and H0 is rejected.
2. If the significance value (Sig.) > 0.05, then Ha is rejected and H0 is accepted.

If the Two-Way ANOVA test results show that Ha is accepted and H0 is rejected, then Duncan's test will be conducted at a significance level of $\alpha = 0.05$ to test for differences between treatments. The results of hypothesis testing using two-way ANOVA at a significance level of $\alpha = 0.05$ using SPSS 26.0 software are shown in Table 5.

Based on Table 5, it can be seen that the results of the SPSS Two-Way ANOVA analysis show that the sig. value for the treatment is 0.002 < 0.05, the sig. value for the species is 0.000 < 0.05, and the sig. value for the treatment*species combination is 0.012 < 0.05. Since all three sig. values are < 0.05, it can be concluded that all three alternative hypotheses (Ha) are accepted, and the null hypothesis (H0) is rejected. This means that there is an effect of mercury solution concentration, species differences, and the combination of mercury concentration and species differences on the mercury (Hg) heavy metal absorption ability in the mangrove crab (*Scylla serrata*), mangrove snail (*Telescopium telescopium*), and mangrove clam (*Polymesoda erosa*).

Table 5. Results of Two-Way ANOVA Analysis Using SPSS Software Ver. 26.0

The concentration of mercury in the environment

Tests of Between-Subjects Effects					
Dependent Variable: Mercury Accumulation					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	2607.769[a]	12	217.314	22.074	0.000
Treatment	284.486	3	94.829	9.632	0.002
Species	625.542	2	312.771	31.770	0.000
Treatment * Species	272.932	6	45.489	4.620	0.012
Error	118.140	12	9.845		
Total	2725.909	24			

a. R Squared = .957 (Adjusted R Squared = .913)

(medium) significantly affects the level of accumulation in biota, which indicates that the higher the mercury concentration in the organism's habitat, the greater the likelihood that the organism will absorb and accumulate it. Mercury has bioaccumulative properties, meaning that organisms exposed to mercury can store this substance in their tissues, and the mercury concentration in these organisms can increase over time. Accumulation of mercury in biota is often directly proportional to mercury concentrations in the environment, with organisms exposed to high concentrations tending to store mercury in their tissues.

Species differences affect the ability of an organism to absorb mercury (Hg). This can happen because of differences in physiological and biochemical factors between species. Some species may have better excretion abilities, while others are more efficient in accumulating mercury. Genetic factors, habitat, and trophic position in the food chain can influence differences in tolerance and the capacity to accumulate mercury among species. This is consistent with Lasut, (2009) who mentioned that various factors the mercury 'uptake' process and the

amount that will accumulate, including metabolic rate and species type.

When looking at the results of mercury metal analysis in biota samples (mud crabs, mud snails, and mud clams) on the first day (a) and second day (b) after treatment (Figure 2), it can be seen that all species have the ability to accumulate mercury although the ability to accumulate varies. Nurdin stated that the process by which heavy metals enter aquatic biota occurs as water diffuses through the gills and is then distributed throughout the body via the bloodstream, leading to the accumulation of heavy metals in the tissue. Mercury enters the body through the skin, respiration, and digestion (Irsan et al., 2023). According to Hasni et al., (2020) in mangrove crabs (*Scylla serrata* mercury accumulation begins through gill uptake and is absorbed into the body tissues. In mangrove snails (*Telescopium telescopium*), mercury accumulates due to their filter-feeding behavior (Samman et al., 2014). For mangrove clams (*Polymesoda erosa*), mercury accumulates because of their filter-feeding feeding habits (Irsan. et al., 2020).

To examine the combination of mercury concentration and species in mercury accumulation, Duncan's test analysis was conducted using SPSS Ver. 26.0, and the results are presented in Table 6.

Table 6. Duncan's Test Analysis Results Using SPSS Software Ver. 26.0

Mercury Accumulation					
Treatment dan Species	N	Subset for alpha = 0.05			
		a	b	c	d
ScA1	2	1.1060			
ScA0	2	1.3525			
ScA3	2	1.9935			
ScA2	2	3.4390	3.4390		
PeA0	2	3.5365	3.5365		
TtA0	2	4.3670	4.3670		
TtA2	2	4.5250	4.5250		
TtA1	2	5.8160	5.8160	5.8160	
PeA1	2		10.8800	10.8800	
TtA3	2			12.3700	
PeA2	2				21.3720
PeA3	2				21.7025
Sig.		0.202	0.053	0.069	0.918

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 2.000.

Table 6 showed that the mercury concentration treatment on mangrove clams (*Polymesoda erosa*) at concentration A2 (5 ppm) did not differ significantly from concentration A3 (10 ppm), and both treatments had the highest mercury accumulation in the samples. This indicates that mangrove clams have a higher mercury accumulation capacity than other species, while mangrove snails have a higher mercury accumulation than mangrove crabs.

The high mercury accumulation capacity in mangrove clams is due to their feeding method as filter feeders. This feeding method involves the organism filtering water, which directly exposes the species to contaminants and accumulates them from their food, making them one of the best mercury accumulators. Irsan., (2015) explains that filter feeder biota obtains food by filtering small particles from the water. Due to their filtration method, filter feeder biota is exposed to high concentrations of mercury from the particles present in the water. Filter-feeder organisms not only accumulate mercury from the water but also from the food they consume. Many tiny organisms, such as phytoplankton and zooplankton, contain mercury. When filter feeder biota consumes this food, they also accumulate mercury in their tissues.

CONCLUSION

Based on the results of the research, the following conclusions can be drawn: The concentration of mercury solution affects the ability of heavy metal mercury (Hg) uptake in mangrove crabs (*Scylla serrata*), mangrove snails (*Telescopium telescopium*) and mangrove clams (*Polymeoda erosa*), where the sig. value for the treatment is 0.002 <0.05. Species differences affect the ability of mercury heavy metal uptake in samples, where the sig. value for species is 0.000 < 0.05. The combination of mercury solution concentration and species differences affects the ability of mercury heavy metal uptake in samples, where the sig. value for the combination of treatment * species is 0.012 < 0.05. Mangrove clams (*Polymeoda erosa*) have higher mercury accumulation ability than mangrove snails (*Telescopium telescopium*) and mangrove crabs (*Scylla serrata*), and mangrove snails (*Telescopium telescopium*) have higher mercury accumulation ability than mangrove crabs (*Scylla serrata*).

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