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Analysis of Cadmium Heavy Metal Content in Blood Cockles (*Anadara granosa*) at Cemara Waters, West Lombok

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ABSTRACT

Blood cockles are widely distributed in the coastal waters of West Lombok and are commonly consumed due to their high nutritional value. However, as filter-feeding organisms, cockles have the ability to bioaccumulate heavy metals, making them effective bioindicators of aquatic pollution. This study aimed to analyze the concentration of Cadmium (Cd) in blood cockles (*Anadara granosa*) and sediments collected from the coastal waters of Pantai Cemara, West Lombok. Sampling was conducted from January to September 2025 at three observation stations determined based on fishermen's information regarding potential pollution sources. The results showed that Cd concentrations in cockles ranged from 0.039 to 0.047 mg/kg, with an average value of 0.044 mg/kg. Cd concentrations in sediments ranged from 0.013 to 0,019 mg/kg, also well below the sediment quality guideline value of 25 mg/kg.

INTRODUCTION

The coastal waters of Cemara Beach require particular attention, especially regarding port-related activities. These activities may affect aquatic organisms such as shellfish inhabiting the area, since port operations including loading and unloading processes, transportation, industrial waste, and domestic waste from surrounding communities can increase heavy metal pollution, particularly cadmium (Cd). Therefore, this study aimed to analyze the concentration of Cd in shellfish and sediments collected from the coastal waters surrounding Cemara Beach, West Lombok.

Cadmium (Cd) is one of the hazardous heavy metals that can contaminate aquatic environments and cause negative impacts on aquatic organisms. Cd is classified as a toxic metal with no biological function in the human body (Gavas *et al*., 2026). This heavy metal is persistent, non-biodegradable, and capable of accumulating in sediments and marine organisms through bioaccumulation and biomagnification processes. Sources of cadmium contamination in coastal areas generally originate from port activities, domestic waste, marine transportation, agriculture, and industrial activities discharged into marine waters. Naturally, cadmium may also enter aquatic environments through weathering processes of rocks that release Cd into soils and eventually into water bodies. In 1983, it was estimated that approximately 1,200–13,400 tons of cadmium were released into aquatic environments worldwide (UNEP, 2010). In addition, Khan *et al.* (2022) reported that mining industries, metallurgy, plastic stabilizers, and battery manufacturing are among the major anthropogenic sources of cadmium pollution. In developing countries, cadmium-containing waste is commonly disposed of together with other wastes, resulting in cadmium accumulation in landfills or direct discharge into aquatic ecosystems (UNEP, 2010).

The presence of Cd in aquatic environments requires serious attention because it can reduce environmental quality and threaten human health through the marine food chain. According to Zou *et al*. (2024), cadmium exposure in humans can increase the production of Reactive Oxygen Species (ROS). Excessive ROS levels may damage proteins, lipids, and DNA, as well as inhibit the formation of antioxidant enzymes, leading to oxidative damage within mitochondria.

Cemara waters in South Lembar Village, West Lombok Regency, represent a coastal area with relatively intensive human activities, including fisheries, coastal tourism, marine transportation, and port operations around the Lembar area. These activities potentially contribute to the introduction of pollutants into the marine environment, including heavy metals such as Cd. According to Subagio (2016), the coastal waters of West Lombok possess relatively high primary productivity, supporting the presence of various marine organisms, including benthic biota and filter feeders that are highly susceptible to heavy metal accumulation from their surrounding environment.

One of the marine organisms commonly found and consumed by coastal communities is the blood cockle, *Anadara granosa*. Blood cockles are benthic organisms that inhabit muddy substrates and exhibit filter-feeding behavior by filtering suspended particles from the water column. This characteristic makes blood cockles highly susceptible to accumulating heavy metals present in both the water and sediment. Therefore, blood cockles are frequently used as bioindicators of heavy metal contamination in coastal ecosystems (Handayani *et al*., 2020).

Several studies have shown that Cd concentrations in blood cockles may increase due to intensive anthropogenic activities in coastal areas. Cd accumulation in blood cockles may pose health risks to humans when consumed continuously because Cd is toxic and may cause disorders of the kidneys, liver, and nervous system. Previous studies regarding heavy metal contamination in the West Lombok region have also been reported, particularly around Lembar Port, where Cd accumulation was detected in surrounding waters. The recorded Cd concentrations ranged from 0.0086–0.0105 mg/L, while the threshold value established by the Decree of the State Minister for Environment No. 51 of 2004 is 0.01 mg/L (Nurhidayati *et al*., 2021.

Based on these conditions, research concerning Cd concentrations in blood cockles from Cemara waters, West Lombok, is important to assess the level of aquatic environmental contamination as well as the safety of seafood consumed by local communities. The findings of this study are expected to provide scientific information regarding the quality of coastal waters and serve as a consideration for sustainable marine environmental management in the West Lombok region.

METHODS

This study was conducted from January to September 2025 in the coastal waters of Cemara Beach, West Lombok, and at the Health Laboratory Center for Testing and Calibration, Mataram. The samples collected consisted of blood cockles and sediments. Sampling was carried out in the coastal area surrounding Cemara Beach. Sampling points were determined based on information obtained from local fishermen who commonly collect shellfish in areas suspected to be sources of pollution. The sampling locations were divided into three stations.

The blood cockles used in this study were collected manually during low tide conditions. After collection, the samples were placed into plastic bags, labeled, and stored in a cool box containing dry ice. Sediment samples were collected from the surface layer at a depth of approximately 0.5 cm with a total weight of 200 g. The sediment was collected using a small shovel, placed into labeled plastic bags, marked using a permanent marker, and subsequently stored in a cool box. Water samples were also collected and transferred into 500 mL sample bottles. All samples were then transported to the laboratory for further analysis.

Sample preparation was carried out using the wet digestion method. Initially, 1–2.5 g of sample was weighed and placed into an Erlenmeyer flask or digestion tube. Subsequently, 25 mL of concentrated HNO_3 was added, and the mixture was allowed to stand overnight. The solution was then heated gradually for approximately 35 minutes to oxidize easily decomposed compounds. After cooling, 10 mL of $HClO_4$ (70–72%) was added, and the solution was reheated at approximately 100°C until all NO_2 gas disappeared. Following the heating process, the solution was cooled again and filtered into a 50 mL volumetric flask. The filtrate was then diluted to the calibration mark, homogenized, and prepared for analysis (Mayholida *et al*., 2020). All samples were subsequently analyzed using Atomic Absorption Spectrophotometry (AAS) at a wavelength of 228.8 nm.

The determination of heavy metal concentrations was performed using a calibration curve. The calibration curve was prepared by measuring the absorbance values of several standard solutions with known concentrations. A graph showing the relationship between absorbance and standard solution concentration was then constructed (Nurhidayati et al., 2021).

An assessment of the safe consumption limit was also conducted in this study to determine the allowable threshold for human consumption of blood cockles contaminated with Cd. The calculation was based on the Provisional Tolerable Weekly Intake (PTWI), which represents the tolerable amount of Cd that can be accepted by the human body within one week. The PTWI value was obtained from the standard established by WHO (2017). Furthermore, the values of Maximum Weekly Intake (MWI) and Maximum Tolerable Intake (MTI) were calculated.

$$\text{MWI} = \text{body weight}^{a} \times \text{PTWI}^{b}$$

Where:

a = The average body weight of Indonesian Adults is 60 kg

b = PTWI is the Provisional Tolerable Weekly Intake established by WHO

$$\text{MTI} = \text{MWI}/\text{Ct}$$

Where:

MTI = Maximum Tolerable Intake (kg/week)

Ct = Concentration of heavy metal content in shellfish (mg/kg)

The collected data were then analyzed descriptively. The data were analyzed based on the results obtained from the AAS instrument and presented in graphical form, while the MTI data were presented in tables.

RESULTS

Based on the results of this study, data on cadmium (Cd) heavy metal concentrations in blood cockles and sediments collected from Cemara Beach, West Lombok, were obtained. The results are presented in Figure 1 and Figure 2.

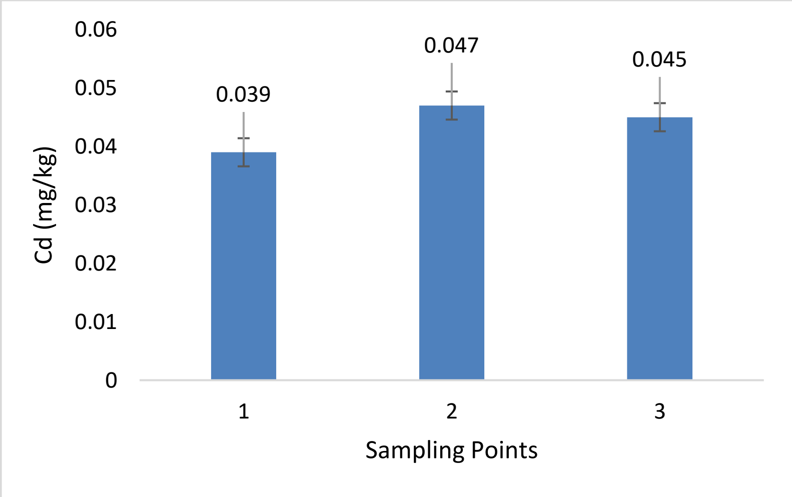

Figure 1. Cadmium Concentration in Blood Cockles

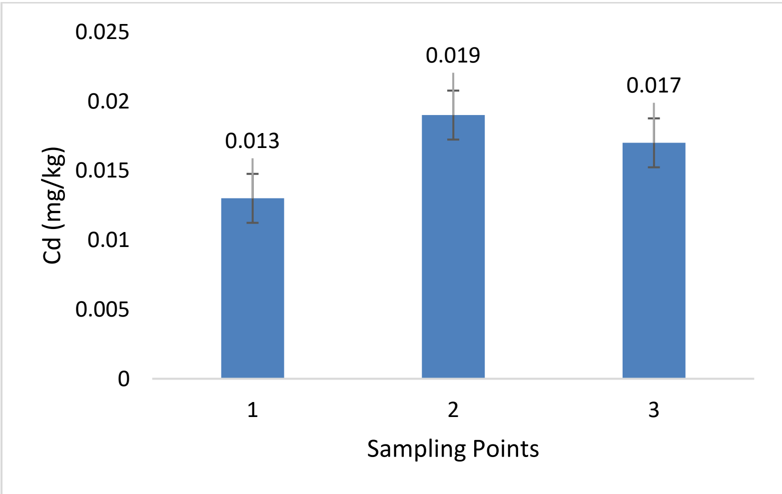

Figure 2. Cadmium Concentration in sediment

Table 1. Safe Consumption Limit of Blood Cockles

Sampling Points	PTWI (µg/kgBB/week)	MWI (mg/week)	MTI (kg/week)
1	7	0.42	10.77
2	7	0.42	8.94
3	7	0.42	9.33

DISCUSSION

The concentration of cadmium heavy metal in blood cockles collected from Cemara Beach, West Lombok, showed relatively low values, respectively 0.039 mg/kg, 0.047 mg/kg, and 0.045 mg/kg, with an average concentration of 0.0444 mg/kg. Based on these results, the Cd concentrations were still below the maximum limit established by the Indonesian National Standard (SNI, 2009), which is 1 mg/kg for shellfish. Referring to this standard, the cadmium concentration in blood cockles from the study area remained below the permissible threshold.

This indicates that, in general, the level of Cd accumulation in blood cockles from Cemara Beach was relatively low and had not exceeded the safe consumption limit.

Cadmium contamination in aquatic environments may originate from domestic activities, agriculture, marine transportation, and port activities. The presence of cadmium in aquatic ecosystems can subsequently accumulate in organisms such as blood cockles, which are sedentary filter feeders. Organisms with these characteristics generally possess higher tolerance to pollution, resulting in greater heavy metal accumulation compared to other organisms. This accumulation occurs because heavy metals are capable of forming complex compounds with organic substances present within the shellfish body (Haryono *et al*., 2017). The mechanism of heavy metal uptake in shellfish may occur through two pathways, namely respiration and digestion. In the respiratory pathway, water enters through the gills and exits through the dorsal siphon. In the digestive pathway, food particles enter through the ventral siphon and are directed into the mouth by ciliary movement. The food then passes through the esophagus and enters the stomach located adjacent to the dorsal visceral mass (Apriyanti, 2018). Subsequently, cadmium forms stable complex compounds and is stored in several organs, including the soft tissues of the shellfish (Andini *et al*., 2024).

The sediment analysis also showed relatively low Cd concentrations, ranging from 0.013–0.019 mg/kg, which were still below the safe limit established by the Australian and New Zealand Environment and Conservation Council (2000), namely 1.5 mg/kg. Cadmium contamination in sediments may originate from residential activities, domestic waste, and shipping activities. Balwa *et al*. (2016) reported that cadmium pollution loads in ballast water from passenger ships at Tanjung Emas Port, Semarang, reached 1.843 mg/L. Cadmium concentrations may continue to increase due to long-term accumulation resulting from continuous inputs over extended periods. According to Nugraha (2009), heavy metal concentrations in sediments are generally higher than those in seawater because heavy metals readily bind to organic materials and precipitate onto the seabed, where they subsequently become incorporated into sediments.

The relatively low concentrations of cadmium in both blood cockles and sediments may be associated with the presence of mangrove ecosystems in the area, despite Cemara waters being located near port activities. According to Atmanegara *et al*. (2020), the mangrove area in Cemara waters covers approximately 88.83 ha. Mangroves play an important role in absorbing heavy metals from aquatic environments. Based on the research of Valentino (2025), cadmium concentrations in mangrove roots from Cemara waters ranged from 0.25–9.76 mg/kg. Mangrove roots are capable of absorbing and retaining heavy metals, thereby reducing heavy metal concentrations in sediments and surrounding waters (Supriyantini *et al*., 2017). The mechanism of heavy metal absorption by mangroves may occur through passive diffusion via the root system (Vasilachi *et al*., 2023). Heavy metals are absorbed in cationic form (positively charged ions dissolved in water). These metals are subsequently stored in the apoplast, which consists of cell walls and intercellular spaces that function as pathways for water and dissolved substances. The heavy metals may then be translocated to the stems and leaves of mangroves (Setiawan, 2013).

The results of the Maximum Tolerable Intake (MTI) calculation indicated that the safe consumption limit of blood cockles for coastal communities in Cemara waters ranged from 8.94–10.77 kg/week. This result was associated with the relatively low cadmium concentrations detected in blood cockles from Cemara waters.

CONCLUSION

The concentration of cadmium (Cd) in blood cockles and sediments collected from Cemara Waters, West Lombok, was relatively low and remained below the permissible limits established by Indonesian National Standard. The average Cd concentration in blood cockles was 0.0444 mg/kg, indicating that the contamination level is still within the safe limit for human consumption. The low accumulation of Cd in blood cockles is closely related to the ecological role of mangrove ecosystems in absorbing and retaining heavy metals through their root systems, thereby reducing metal availability in surrounding waters and sediments. In addition, the calculated Maximum Tolerable Intake (MTI) value showed that blood cockles from Cemara Waters are still safe for consumption within the recommended intake range.

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