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Concentrations of Heavy Metals Pb and Cd in *Porites lutea* Coral in Mandalika Coastal Waters

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ABSTRACT

The Mandalika Coastal Area, located in Central Lombok Regency, is a row of beaches and bays that have a large coral reef ecosystem and intertidal zone area. The increasing growth of activities on the Mandalika coast will affect the life of the coral reef ecosystem, one of which is the concentration of heavy metals that exceeds the quality standard limits which will be very dangerous for coral reefs. This study aims to determine the concentration of the heavy metals lead and cadmium in Porites lutea coral reefs in Kuta, Tanjung Aan and Gerupuk beaches. Research data collection (field and laboratory) was carried out in May 2023. Coral reef preparation was carried out at the Advanced and Analytical Biology Laboratory, FMIPA, University of Mataram and measurements of heavy metal content were carried out at the Environmental Laboratory, the West Nusa Tenggara Province Environment and Forestry Service. Measurement and calculation of heavy metal content using Atomic Absorption Spectrophotometry (AAS). The results showed that the concentrations of the heavy metals lead and cadmium in *Porites lutea* coral reefs are < 0.0005 mg/L and < 0.0001 mg/L, which are still below the quality standards (PPRI No.22 of 2021 concerning Sea water Wuality Standards on Marine Biota). The Bioaccumulation Factors (BAF) value in all samples of *P. lutea* coral in Mandalika coastal waters is 0.00 mg/L, this shows that there is no accumulation of heavy metals in *P. lutea* coral.

Keywords: *Cadmium; Coral; Heavy Metals; Lead; Porites; Mandalika*

INTRODUCTION

The Mandalika Coast is part of the Special Economic Zone, which is rapidly developing in the fields of tourism, economy and culture, making it an important area. The Mandalika Coastal Area consists of a collection of beaches and bays with coral reef ecosystems and a fairly large intertidal zone area, located in Central Lombok Regency (Nurhaliza et al., 2019). Several beaches and bays that are well known to the public, namely Kuta Beach, Aan Beach, Gerupuk Beach, and Seger Bay can be found along Mandalika Beach (Ahyadi et al., 2021).

Ecosystems that have very high productivity on the coast, apart from seagrass and mangrove habitats, namely coral reefs, are very vital ecosystems for living creatures (Suryanti et al., 2019). Because the porites coral skeleton is very sturdy, its presence in the sea is often thought to protect beaches from abrasion. Because the skeleton is a good recorder of changes in temperature, nutrients and pollutants, massive porites coral can also be used as a source of data on the state of the aquatic environment in the past (Luthfi et al., 2016). Heavy metals are basic components required by all organisms. Essential heavy metals, for example zinc (Zn), copper (Cu) and iron (Fe), are needed at reasonable concentrations to keep the metabolism of living organisms functioning. On the other hand, non-essential heavy metals, such as cadmium (Cd), lead (Pb) and mercury (Hg) are very toxic and useless for living organisms (Rusnam and Efrizal, 2020). Marine pollution occurs due to human activities around the coast of Mandalika, such as household waste and

tourists hotels, workshop and also infrastructure development. The waste contains various elements or compounds or particles of one of them are heavy metals such as lead and cadmium.

There are two main types of activities on Mandalika beach, namely fishing and tourism. The three beaches of Kuta, Aan, and Gerupuk have a number of similarities in terms of tourism and fishing activities. The water conditions in the bay are quite safe with waters that are generally calm and shallow, this tourist activity is spread throughout almost the entire Mandalika coastal area. Sunbathing on the beach, swimming, snorkeling, diving and surfing are some of the tourist activities on the Mandalika coast. Madak, fishing, archery, and catching bottom and surface fish are some examples of fishing activities on the Mandalika coast. The Tanjung Aan coast basically has several activities that are identical to those on Kuta Beach, including tourism and fishing. Meanwhile, tourism-related activities such as diving and surfing are complemented by cultivation (fish, lobster and seaweed) and capture fisheries in the Gerupuk Bay area (Apriani et al., 2022).

Based on the results of monitoring of sea water quality on the Mandalika coast by ITDC (Indonesia Tourism Development Corporation) in December 2022, it was found that the results for the heavy metal parameters cadmium and lead had exceeded the threshold. This limit is based on Republic of Indonesia Government Regulation No. 22 of 2021 concerning Sea water Quality Standards for Outdoor Biota. Sea water quality monitoring locations are carried out in four locations, namely Kuta Bay, Gerupuk, Seger and Aan. The heavy metal lead (Pb) has a value in the range of 0.006 – 0.093 mg/L (>0.005 mg/L), then the heavy metal cadmium (Cd) has a value in the range 0.014 – 0.027 mg/L (>0.002 mg/L). Concentrations of heavy metals that exceed quality standard limits will be dangerous for marine biota, especially coral reefs.

Based on Nurhaliza et al. (2019), there are 3 types of coral reefs in the *Porites* genus, namely *Porites lutea, Porites lobata* and *Porites cylindrica* on the Mandalika Coast, which are spread across the beaches of Kuta, Tanjung Aan and Gerupuk (Suana et al., 2019). The increasing amount of waste from human activities in the Mandalika coastal area will be carried away by rainwater and end up in coastal waters. It is very likely that these wastes will settle at the bottom of the waters, and some of them will accumulate heavy metals in coral reefs, especially *Porites lutea* which is a type of coral reef. The massive *P. lutea* coral reef has the potential to be a bioindicator of metal pollutants in waters because it can record lead and cadmium. The health of coral reefs and the biota that live on the seabed will be influenced by the status of polluted waters in the coral reef ecosystem (Mellawati and Bachtiar, 2011).

Heavy metals do not decompose in water, but can be absorbed. The importance of coral reef life and the increasing concentration of heavy metals, it is necessary to know about the heavy metal content in marine biota, especially coral reefs. Research related to heavy metals on coral reefs, especially *Porites lutea*, is still very rare. This research aims to provide information regarding heavy metal concentrations in *Porites lutea* coral in Mandalika Coastal Waters.

METHODS

This research was carried out in May - June 2023. *Porites lutea* coral reef samples were taken on the Mandalika coast, namely Kuta beach, Aan beach and

Gerupuk beach (**Figure 1**). Determining the sampling location for *Porites lutea* coral reefs in the Mandalika coastal area was carried out using purposive or deliberate sampling. This is based on the existence of a coral reef ecosystem on the Mandalika coast (Riska et al., 2022). These three locations are expected to show how much heavy metal lead and cadmium the *Porites lutea* coral currently contains.

Sampling and Environmental Parameters

At each station, 200 gr samples of *P. lutea* coral with a diameter of more than 10 cm were taken measuring ± 5 cm with a hammer and then wrapped in ziplock plastic (Riska et al., 2022). Environmental parameter measurements are carried out together with sampling activities. The environmental factors taken are temperature, degree of acidity, salinity and current speed.

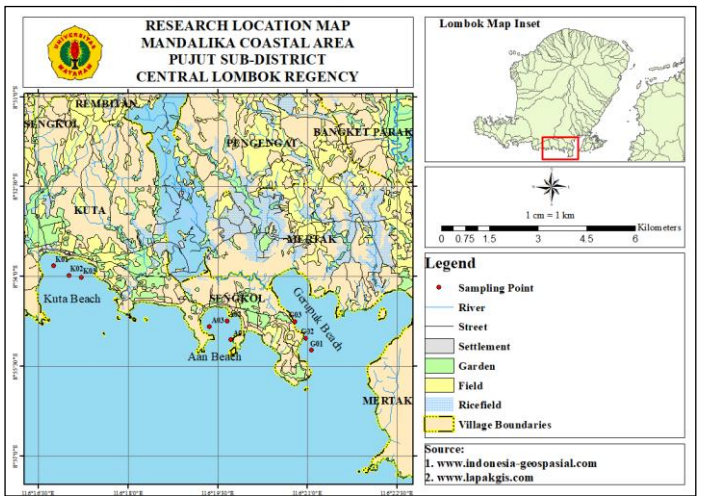

Figure 1. Map of Sampling Locations for *Porites lutea* Coral in Mandalika Coastal Waters

Coral Reef Preparation

Preparation at the Advanced Biology Laboratory, Faculty of Mathematics and Natural Sciences, Mataram University, carried out a process of reducing water content (oven) and grinding to make it easier in the digestion stage. The process begins with the coral sample being heated in an oven at a temperature of 105°C. This oven is carried out for 24 hours to reduce the water content in the coral reefs, so that the coral reefs are easier to grind. Samples that had been in the oven for 24 hours were then ground again using a mortar so that the samples could easily dissolve during the digestion process.

The next process is destruction which is carried out at the Analytical Laboratory, Faculty of Mathematics and Natural Sciences, Mataram University. The crushed sample was then weighed into an analytical balance of 0.1 gram. Then weigh 1 gram of catalyst (Na_2SO_4 + $CuSO_4$) and put it into the Kjeldahl flask together with the sample. The sample was then added with 8 mL of sulfuric acid (H_2SO_4) and heated with a hot plate. Heating was carried out for 2 hours, then cooled to room temperature. The heated sample was then transferred to a 100 mL volumetric flask with the addition of a little distilled water and the filtering process was carried out using filter paper. After adding distilled water until it reaches a volume of 100 mL, the sample is then homogenized. Samples were placed in dark glass sample bottles according to heavy metal sample storage standards.

Heavy Metal Content Testing

Testing for the heavy metal content cadmium (Cd) and lead (Pb) was carried out at the Environmental Laboratory, NTB Provincial Environment and Forestry Service. Measurement and calculation of cadmium and lead content in *P. lutea* coral reefs was carried out based on a calibration curve by measuring the absorbance of standard solutions and sample solutions using a Thermo Scientific iCE 3000 Atomic Absorption Spectrophotometer (AAS).

Calculation of Bioaccumulation Factors (BAF)

Bioaccumulation is the process by which chemical substances are absorbed in organisms through all routes of exposure as they occur in the natural environment, i.e. environmental sources. Calculation of the Bioaccumulation Factor (BAF) of the hard coral *P. lutea* uses the following equation (Arnot and Gobas, 2006 in Samawi et al., 2018):

$$BAF_{water} = \frac{[\text{heavy metal}]c}{[\text{heavy metal}]w}$$

Information:
BAFwater = Bioaccumulation Factor
[heavy metal]c = heavy metal concentration in coral
[heavy metal]w = concentration of heavy metals in water

Comparison of Quality Standards

Based on Republic of Indonesia Government Regulation no. 22 of 2021 concerning Sea water Quality Standards. This Sea water Quality Standard is divided into 3 parts, namely Marine Biota, Harbors and Marine Tourism. The Heavy Metal Parameter Lead has a quality standard value of 0.008 mg/L, while the Heavy Metal Cadmium has a quality standard value of 0.001 mg/L.

RESULTS AND DISCUSSION

Heavy metal concentrations of *P. lutea* coral samples and location conditions/environmental parameters at sampling locations in 3 coastal waters of the Mandalika coastal area are shown in **Table 1** and **Table 2**.

Table 1. Heavy Metal Concentrations in *Porites lutea* Coral Reefs

Parameter	Metal Content (mg/L)			Quality Standards (mg/L)
	Kuta	Aan	Gerupuk	
Lead (Pb)	< 0.0005			0.008
Cadmium (Cd)	< 0.0001			0.001

Note: conversion 1 ppm = 1 mg/L

Table 2. Environmental Conditions of Coral Reef Sampling Locations

Parameter	Beach		
	Kuta	Aan	Gerupuk
Temperature (°C)		27	
Salinity (ppm)	33.67	35	35
pH	7.32	7.31	7.24
Current Speed (m/s)		0.1	

The results of the analysis of the metal concentration of Lead (Pb) in the *P. lutea* coral showed the same average value on the three beaches. The concentration of the heavy metal Lead on each beach, namely Kuta, Aan and Gerupuk showed a heavy metal content of < 0.0005 mg/L. The tool detection limit for AAS is < 0.0005 mg/L. Based on the measurement results above, the concentration of the heavy metal Lead in the *P. lutea* coral reef still has not passed the quality standard. Meanwhile, the results of the analysis of the cadmium metal content in the *P. lutea* coral showed the same average value on the three beaches. The concentration of the heavy metal Cadmium (Cd) on each beach, namely Kuta, Aan and Gerupuk showed a heavy metal content of < 0.0001 mg/L. The detection limit of the instrument on the Thermo Scientific iCE 3000 AAS (Atomic Absorption Spectrophotometer) is < 0.0001 mg/L. Based on the test results above, the concentration of the heavy metal Cadmium in the *P. lutea* coral reef still has not passed the quality standard. Based on the results of these heavy metal measurements, this is different from the concentration of heavy metals cadmium and lead in seawater, test results from ITDC in 2022.

The high concentration of heavy metals in the waters apparently has not yet accumulated on coral reefs in Mandalika coastal waters, because the accumulation of heavy metals in living creatures such as coral reefs takes a longer period of time. This is in accordance with the statement by Samawi et al. (2018) that animals called Porites hard corals have a long lifespan and can store heavy metals that come from the environment. Marine biota in Mandalika's coastal waters were still not polluted by the heavy metals lead and cadmium, so Mandalika's coastal waters are categorized as not polluted.

The Mandalika coast is a coastal area that faces the open sea, namely the Indian Ocean. Beaches in the southern area of the island are more dominant in experiencing abrasion phenomena and have deeper water characteristics and have larger currents and waves than beaches in the northern area (Minarrohman and Pratomo, 2017). This shows that the processes of transport, deposition and distribution of sediment that take place in the aquatic environment will be influenced by current speed. Sediment distribution is influenced by current speed, with coarser sediment grains found in areas with faster currents and finer sediment deposited in areas with slower currents (Nugroho and Basit, 2014). The high current speed on the Mandalika coast causes little sedimentation to occur on coral reefs so that material carried from land will be difficult to settle at the bottom of the waters. Coral polyps will continue to be rinsed and washed by waves and ocean currents and it will be difficult for them to accumulate heavy metals on the coast.

Heavy metals can enter through coral body tissue by three methods: (a) the food chain process, especially plankton which already contains heavy metals; (b) use of mucus tissue to hunt for food, in this process it is not just plankton but sediment that is trapped and then enters the coral body; and (c) the process by pushing or pressing the mesenteric filaments. The presence of heavy metals in coral calcium carbonate ($CaCO_3$) skeletons is caused by several mechanisms, including the replacement of calcium with certain metals and the entry of detritus carrying heavy metals into the pores of the skeleton (Dodge et al., 1984 in Panuntun et al., 2012).

Based on calculations, it is known that the Bioaccumulation Factor (BAF) value for all *P. lutea* coral samples in Mandalika coastal waters is 0.00 mg/L. This

indicates that there is no accumulation of heavy metals in *P. lutea* coral. The results of research by Samawi et al. (2018) stated that the accumulation of the heavy metal lead by the hard coral *P. lutea* ranged from 297.2 - 347 times the concentration in sea water. Thus, it proves that the hard coral *P. lutea* is a fairly large bioaccumulator of heavy metals from the waters. The results of BAF calculations for heavy metals from sediments show that *P. lutea* accumulates 4–10 times in sediments. These results prove that very small amounts of heavy metals accumulate from sediment when compared to water.

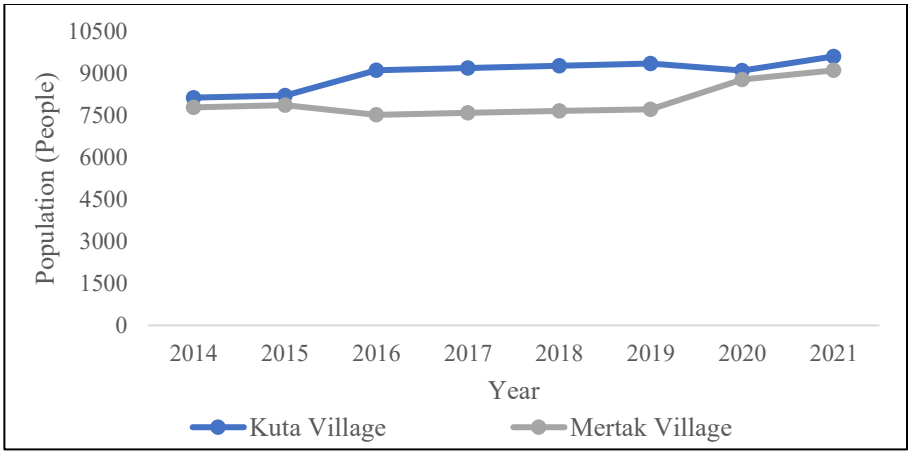

Figure 2. Changes in Population on the Mandalika Coast

As a result of the use of these metals in human activities which produce waste that pollutes waters, contamination by heavy metals occurs. This is in accordance with the number of economic activities and population on the Mandalika coast in **Figure 2** especially the two villages that cover the Mandalika coast, namely Kuta village and Mertak village. Based on data from the Pujut District Central Statistics Agency, this increase in population increased during the designation as a Special Economic Zone since 2014 (**Figure 3**). Mandalika coastal waters is one of the waters that has the potential for environmental changes due to the disposal of construction waste, shops, hotels, accommodation and households.

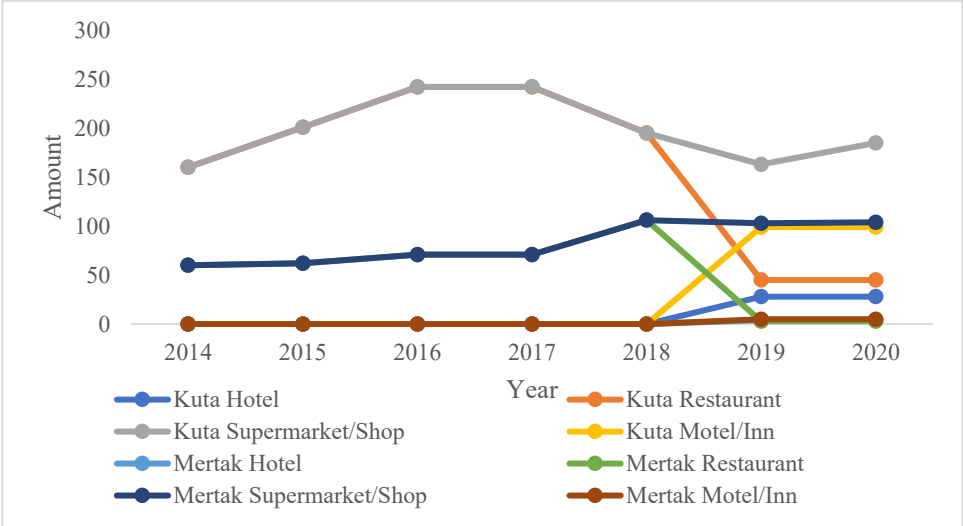

Figure 3. Data on Economic Activities on the Mandalika Coast

B3 waste (Hazardous and Toxic Materials) are chemicals or elements that have the potential to pollute, harm or endanger human health and the environment, as well as the survival of other species due to different types, concentrations or numbers of life (Iswanto et al., 2016). Based on the Central Bureau Statistics (BPS) of Pujut District in 2020, the number of hotels in Kuta village was recorded at 28 hotels, 99 inns or motels, 45 restaurants and 185 supermarkets or grocery stores. Most of the activities of tourists, hotels and business actors on the Mandalika coast produce B3 waste, such as batteries, lamps, electronic equipment, clothes and floor cleaners.

The activities currently occurring on the Mandalika coast do not rule out the possibility that accumulation will occur in the future. If there is no further management regarding waste processing, then not only the water and coral reefs will be polluted. This can also affect other biota, such as fish and mollusks consumed by the people and tourists of the Mandalika coast. This will be dangerous if the metal has accumulated in humans over a long period of time.

CONCLUSION

Concentrations of the heavy metals cadmium and lead in *P. lutea* coral at three locations, namely Kuta, Aan and Gerupuk beaches, are below the threshold of 0.008 mg/L and 0.001 mg/L (PPRI No. 22 of 2021 concerning Sea water Quality Standards for Marine Biota) . Then the Bioaccumulation Factors (BAF) value for all *P. lutea* coral samples in Mandalika coastal waters was 0.00 mg/L. This shows that there is no accumulation of heavy metals in *P. lutea* coral. The coral reef biota that lives on the coast of Mandalika is still not contaminated by the heavy metals cadmium and lead, so Mandalika's coastal coral reefs are categorized as not polluted.

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