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Impact of human activities on coral metric diversity and disease prevalence in Padamarang and Wangi Wangi Islands, Southeast Sulawesi, Indonesia

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Abstract. *Palupi RD, Haya LOMY, Sabdaningsih A, Ayuningrum D, Sabdono A. 2025. Impact of human activities on coral metric diversity and disease prevalence in Padamarang and Wangi Wangi Islands, Southeast Sulawesi, Indonesia. Biodiversitas 26: 1334-1342.* Coral diseases are emerging throughout Southeast Sulawesi, Indonesia which might be due to local anthropogenic stressors. This study aims to investigate the impact of anthropogenic stress on coral cover and the prevalence of coral disease in Padamarang (uninhabited) and Wangi Wangi (inhabited) Islands. Data were observed and collected by Scuba Diving in these sites in February-March 2023. The prevalence of diseases was calculated as the mean percentage of coral colonies affected by disease per 100 m^2 belt transect. The findings indicated both sites showed relatively similar values for Genus Richness, H-index, and Evenness, suggesting comparable ecological diversity across the sites. Specifically, Padamarang exhibited a slightly lower Genus Richness (11.24 vs 12.48), and its Evenness value was also marginally higher (0.61 vs 0.58 in Wangi Wangi). However, the statistical significance of the abundance differences suggests that Wangi Wangi may support a denser coral population overall. *Porites* sp. showed a particularly high rate of infection, with White Syndrome, White Band Disease, and Black Band Disease being the most frequently observed illnesses. It is expected that the results of this research will provide better insight into the impact of anthropogenic stress on coral reef health and encourage further conservation efforts to safeguard this important coral ecosystem.

Keywords: Anthropogenic, coral disease, diversity, prevalence, Wakatobi

INTRODUCTION

Coral reefs are highly valuable marine ecosystems because of the biodiversity and ecological benefits they offer. However, these ecosystems are increasingly threatened by challenges, especially anthropogenic stress, originating from human activities such as increasing urbanization, tourism, pollution, and climate change (Fine et al. 2019). One of the serious impacts of anthropogenic stress on coral reefs is the emergence of coral disease outbreaks (Jones et al. 2021; Setter et al. 2022). Coral disease outbreaks have become a global issue of concern, causing serious damage to coral reefs throughout the world (Walker et al. 2021; Zakaria et al. 2021).

Coral diseases occur due to interactions between corals as hosts, direct causative agents, and the aquatic environment. These three factors are commonly referred to as the triangle of disease (Bruno 2015). Environmental factors are suspected to trigger the presence and virulence of pathogenic microorganisms. Several cases of coral diseases in certain waters are caused by infections from pathogenic microorganisms, environmental conditions that facilitate infection, and weakened coral immunity (Thompson et al. 2014; Brown et al. 2021). For example, some studies have revealed that rising sea surface temperatures can lead to the emergence of Black Band Disease (BBD) (Aeby et al. 2020). This temperature increase may result from ballast water discharges, thermal waste from industrial activities, or the effects of global warming. The issue of plastic waste has also been linked to the occurrence of White Syndrome (WS) in corals (Muhammad et al. 2021).

Although much research has been conducted to understand the causes and impacts of coral disease outbreaks, there are still many unanswered questions. Previous studies have tended to focus on environmental factors such as changes in water temperature and water quality as the main drivers of coral disease outbreaks (Browne et al. 2015). However, not many studies have examined the role of anthropogenic stress and coral cover in influencing the occurrence of coral disease outbreaks in various coral reef locations. Aeby et al. (2021) conducted a comparative study of coral disease in three regions along the Saudi Arabian coast of the central Red Sea and concluded that the increase in the prevalence of coral disease was due to hydrothermal warming. In Indonesia, studies conducted in West Sumatera Sea obtained a prevalence value of disease and coral health disorder as well as 71% (Zakaria et al. 2021), in Panjang Island, Jepara as big 74.37% (Sabdono et al. 2014), as well as 15% for coral disease and 14% for coral compromise health in Kessilampe Waters, Kendari (Palupi et al. 2018).

Human activities, or anthropogenic influences, pose significant threats to coral reefs (Freed and Granek 2014). Pollution, overfishing, destructive fishing methods such as dynamite or cyanide use, coral mining for construction materials, and climate change are just a few of the numerous ways in which human actions harm reefs globally (El-Naggar 2021). Economic pressures, societal priorities, and ineffective legal or administrative systems often contribute to the degradation of these vital ecosystems. Anthropogenic effects are also evident on Bokori Island, Southeast Sulawesi-Indonesia. This island serves as both a tourist destination and a fishing area for local fishermen. According to research by Johan et al. (2021), the use of environmentally unfriendly fishing methods has resulted in live coral cover on Bokori Island being classified as moderate (50.67%). The prevalence of fish bombing has led to Dead Coral Algae (DCA) cover reaching 37.33%, damaging the ecosystem and promoting algae growth, which competes for space and resources with coral biota

In these areas, the most significant threat to reefs might be due to human activities, such as overfishing, destructive fisheries, and tourism activities. Hence, this study aims to investigate the anthropogenic impact on the metric diversity and the occurrence of coral disease prevalence on the Padamarang (uninhabited) and Wangi Wangi (inhabited) Islands. Through this case study, we hope to provide a deeper understanding of how anthropogenic stress can be a major driving factor in coral disease outbreaks in various coral reef locations, as well as highlight the importance of conservation and sustainable management in protecting these coral ecosystems.

MATERIALS AND METHODS

Study area

Padamarang is located in the Bay of Bone and close to the mainland of Southeast Sulawesi, Indonesia. Meanwhile, Wangi Wangi is located in open water facing the Banda Sea, and far from Southeast Sulawesi's mainland (Figure 1). Padamarang and Wangi Wangi Islands are two interesting locations to study due to the face of different anthropogenic pressures. Padamarang Island (4°07′42″S, 121°24′51″E), an uninhabited, pristine area, is one of the small islands in the Kolaka District that has a very interesting potential and natural beauty and has become a marine tourism destination as well as one of the fishing grounds. Meanwhile, Wangi Wangi (5°21′10.01″S, 123°29′36.98″E) is densely populated and is part of the Wakatobi District. Most of the local community are fishermen engaged in coastal areas. Such conditions might affect the sustainability of coral reefs, particularly for metric diversity, coral health, and diseases in both sites.

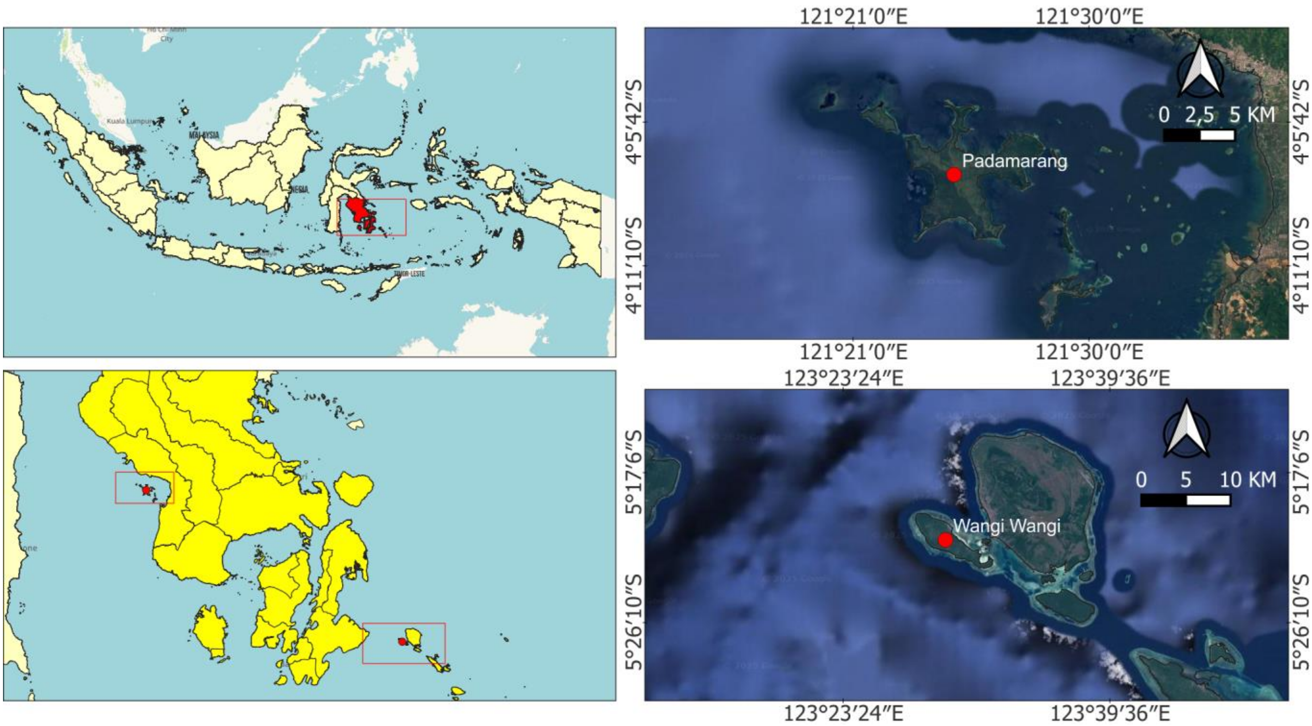

Figure 1. Location of Padamarang and Wangi Wangi Islands, South Sulawesi waters, Indonesia, indicating the sampling sites of coral reefs

Procedures

Preparation and collection of coral and water quality data

Station points were determined using a purposive sampling method based on the presence of coral disease and the suspected causes of environmental stressors, for example, close to settlements, the mainland, and ship traffic, and each location consists of two station points. Furthermore, the tools used in this study were a Global Positioning System (GPS) for plotting the coordinates of station points, scuba diving for data collection, photo frames/transects made of iron with a diameter of 6 mm and a size of 58x44 cm as a frame for taking photos of coral reefs by Underwater Photo Transect (UPT), roll meter/scale tape (50 m) for making transects, underwater or waterproof paper for collecting coral disease data, hand counter for counting coral colonies, underwater camera for taking UPT pictures and documentation of underwater data collection, water quality checker for measuring oceanographic parameters including temperature, salinity, pH, and dissolved oxygen, Nansen bottles to sample water for measuring marine nutrients.

Coral diseases

Coral disease data consisted of prevalence at the study site and were collected using a belt transect with an area of 100 m^2 (50x2 m) and three replications at each station. The belt transect was stretched parallel to the shoreline, while coral disease data were collected at 5 m in Padamarang waters (reef slope) and 3 m in Wangi Wangi (reef flat). Furthermore, the types of coral disease present in the transect were counted and identified. The disease was identified based on the genus/type/growth of infected coral, lesion pattern, lesion color, and margin/lesion shape. A side from counting infected coral colonies, the total number of colonies in the belt transect was also calculated, and then coral disease prevalence values were analyzed.

Coral cover percentages

The condition of coral reefs was taken by finding the percentage of benthic stratum (base substrate benthic) with the Underwater Photo Transect (UPT) method. A 50 m long line transect as a guideline was laid parallel to the shoreline with three replications. The location of condition data was the same as coral disease data. Data collection was carried out by two divers, one holding the frame and the other diver in charge of taking pictures. The pictures were taken with photo frames per meter starting from the 1^{st} m to the 50^{th} m, hence, a total of 50 photos were obtained. Shooting at the 1^{st}/odd m, the frame was placed to the left of the transect line, the 2^{nd}/even m to the right of the line, and further until the 50^{th} m.

Data analysis

Parameters observed included coral damage, underwater photography, oceanographic parameters, type and number of corals per transect, number (healthy/sick coral), and percent coral cover. To determine the prevalence and coral cover, the formula was adopted from (Raymundo et al. 2008):

$$\text{Prevalence} = \frac{\sum \text{Diseased coral colonies}}{\sum \text{Total colonies}}$$

$$\text{Species Richness} = \frac{S-1}{\text{Log } N}$$

$$\text{Diversity index}: H' = \sum_{i=1}^{s} Pi \ln Pi$$

$$\text{Evenness}: E = H'/\ln S$$

Where, *pi*: relative abundance; S: species richness; H': diversity index, and E-evenness.

The t-test was used to analyze the anthropogenic impact on disease prevalence, coral cover, and biological diversity of corals between islands by using SPSS-22 software.

RESULTS AND DISCUSSION

Metric diversity of the coral community

Biodiversity denotes the assortment of living organisms present within a specific area. Coral reefs are widely believed to possess the greatest biodiversity among all ecosystems globally, surpassing even tropical rainforests (Coral Reef Alliance 2024). The diversity of reefs and the habitats they offer to various species yield numerous benefits. For instance, reef-based fisheries supply food and generate income, and activities such as diving and snorkeling at reefs contribute to local economies (Cusack et al. 2021). Economically, this ecosystem contributes a value of 6-15 billion IDR/ha/year to humans (Ramadhan et al. 2017). This economic value can take the form of fishery resources, marine ecotourism, or physical protection as coastal barriers. In this study, a total of 2666 individual reef colonies were recorded with the detailed colony number in Padamarang and Wangi Wangi being 1063 and 1603 respectively, including 45 genera from 14 different families with the detailed colony number in Padamarang and Wangi Wangi being 1063 and 1603 respectively. Moreover, the values of Genus Richness, H-index, and Evenness in Padamarang and Wangi Wangi are 11.24, 2.14, 0.61 and 12.48, 2.13, 0.58, respectively (Table 1).

Based on Table 1, the diversity and evenness indices for Padamarang waters are slightly higher compared to Wangi Wangi. These values indicate that, in general, the coral reefs in both locations exhibit a moderate level of diversity, with no significant imbalance in genus distribution. Although the genus richness in Wangi Wangi is slightly higher compared to Padamarang, the genus distribution in Wangi Wangi shows a slight dominance, particularly by *Porites*, which has a Relative Abundance (RA) value of 0.5. This dominance may be attributed to anthropogenic influences from the local community. Wangi Wangi is a small Island, densely populated island with high levels of fishing and tourism activities.

Coral coverage and life-form

The coral reefs at the two study sites showed different conditions both in coral coverage and lifeform (Figures 2 and 3). The percentage of coral cover on Wangi Wangi Island, Wakatobi was higher than that on Padamarang Island, Kolaka. The coral cover percentages in Wangi Wangi and Padamarang were in the moderate category (47%) and poor category (23%), respectively. The condition of coral reefs in Wangi Wangi has declined compared to previous studies. Research by Husmayani et al. (2021) reported an average live coral cover of 53.7% in the waters of Sombu (Wangi Wangi), classifying it as good, whereas the Dead Coral Algae (DCA) and abiotic percentage in Padamarang were higher than that of Wangi Wangi.

Table 1. Metric diversity on Padamarang and Wangi Wangi Islands, Southeast Sulawesi, Indonesia

Family	**Genus**	**Padamarang**		**Wangi-Wangi**	
		Total	**RA**	**Total**	**RA**
Acroporidae	*Acropora*	62	0.0583	79	0.0493
	Anacropora	13	0.0122	16	0.0100
	Astreopora	14	0.0132	1	0.0006
	Montipora	54	0.0508	113	0.0705
Agariciidae	*Coeloseris*	0	0.0000	17	0.0106
	Leptoseris	31	0.0292	8	0.0050
	Pachyseris	7	0.0066	5	0.0031
	Pavona	2	0.0019	27	0.0168
Astrocoeniidae	*Palauastrea*	3	0.0028	2	0.0012
Caryophylliidae	*Catalaphyllia*	1	0.0009	3	0.0019
	Euphillia	6	0.0056	1	0.0006
Dendrophylliidae	*Turbinaria*	2	0.0019	54	0.0337
Faviidae	*Australogyra*	0	0.0000	2	0.0012
	Echinopora	2	0.0019	2	0.0012
	Favia	49	0.0461	48	0.0299
	Favites	28	0.0263	68	0.0424
	Goniastrea	18	0.0169	31	0.0193
	Herpolita	0	0.0000	5	0.0031
	Leptastrea	16	0.0151	12	0.0075
	Montastrea	1	0.0009	1	0.0006
	Montastrea	0	0.0000	1	0.0006
	Oulastrea	0	0.0000	3	0.0019
	Platygyra	0	0.0000	4	0.0025
	Plesiastrea	0	0.0000	2	0.0012
Fungiidae	*Cycloseris*	2	0.0019	0	0.0000
	Ctenactis	9	0.0085	28	0.0175
	Fungia	173	0.1627	138	0.0861
	Halomitra	0	0.0000	4	0.0025
	Sandalolitha	1	0.0009	1	0.0006
Merulinidae	*Hydnopora*	0	0.0000	2	0.0012
	Scapophyllia	11	0.0103	33	0.0206
Mussidae	*Acanthastrea*	8	0.0075	5	0.0031
	Lobophyllia	1	0.0009	3	0.0019
	Symphyllia	11	0.0103	15	0.0094
Oculinidae	*Galaxea*	13	0.0122	3	0.0019
Pectiniidae	*Pectinia*	5	0.0047	1	0.0006
	Echinophyllia	1	0.0009	0	0.0000
Pocilloporidae	*Pocillopora*	17	0.0160	53	0.0331
	Seriatopora	4	0.0038	5	0.0031
	Styllopora	0	0.0000	1	0.0006
Poritidae	*Alveopora*	11	0.0103	4	0.0025
	Goniopora	2	0.0019	0	0.0000
	Porites	479	0.4506	791	0.4934
Siderastreidae	*Pseudosiderastrea*	3	0.0028	0	0.0000
	Psammocora	3	0.0028	11	0.0069
Total colony	Total colony	1063		1603	
Total genera	Total genera	35		41	
Genus Richness	Genus Richness	11.24		12.48	
H-index	H-index	2.1447		2.1297	
Evenness	Evenness	0.61		0.58	

The benthic stratum in Padamarang was dominated by rabble and sand (abiotic), while in Wangi Wangi apart from live coral, it was also dominated by dead coral. Anthropogenic factors at both locations, particularly in Wangi Wangi, also serve as indicators of increasing coral reef degradation. Population growth in coastal areas can lead to anthropogenic activities such as overfishing, runoff, coastal development, and eutrophication. Over time, these activities can create environmental conditions unsuitable for coral growth, ultimately resulting in heightened coral reef degradation (Castañeda-Chávez et al. 2018; Setter et al. 2022).

The high percentage of dead coral algae is believed to be linked to human activities. Specifically, some local communities may be fishing, even though this region is officially designated as a tourism zone where no fishing is permitted. Nonetheless, certain individuals might ignore these rules and employ harmful fishing practices, such as the use of cyanide. The Rubble (R), which represents broken coral, is mainly attributed to tourism-related activities, such as diving and snorkeling, and stepping on the coral reefs.

The category Rubble (R), representing broken coral, is caused by tourism activities where many visitors engage in diving and snorkeling, leading to tourists stepping on the coral reefs. Another cause is foreign vessels entering the area and anchoring indiscriminately, resulting in damage to the coral reefs. The coral rubble that forms the substrate of the waters can eventually lead to coral diseases and health disturbances if such conditions persist over the long term (Setter et al. 2022). Several previous studies showed the effects of anthropogenic activities on coral damage. El-Naggar (2021), stated that the increase in both human activities and natural stressors is the main cause of coral reef degradation. Similarly, Otaño-Cruz et al. (2017) reported that coral stress resulting from high terrestrial sedimentation input due to local land use practices has been observed along the coast of Puerto Rico, leading to a decline in coral cover in the region. Massei et al. (2023) stated that key stressors for the degradation of the Seixas coral reef ecosystem in Brazil were driven by the increased urbanization and tourism.

The variety of coral lifeforms in Wangi Wangi, with 14 types, surpassed that of Padamarang, which had only 7 types, as illustrated in Figure 3. In Wangi Wangi, massive corals were the most prevalent, followed by branching, submassive, and foliose types. In contrast, Padamarang was dominated by branching corals, followed by massive, encrusting, and submassive forms. These coral assemblages are well-suited for fostering coral ecosystems. Mixed assemblages featuring both branching and massive species are ideal for creating the complex 3D structures of reef systems, which provide refuge for a variety of marine life and enhance resilience to environmental changes (Burns et al. 2019).

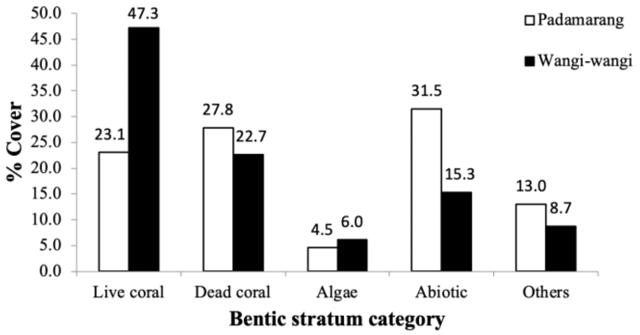

Figure 2. Bottom cover of Padamarang and Wangi Wangi Islands, Southeast Sulawesi, Indonesia

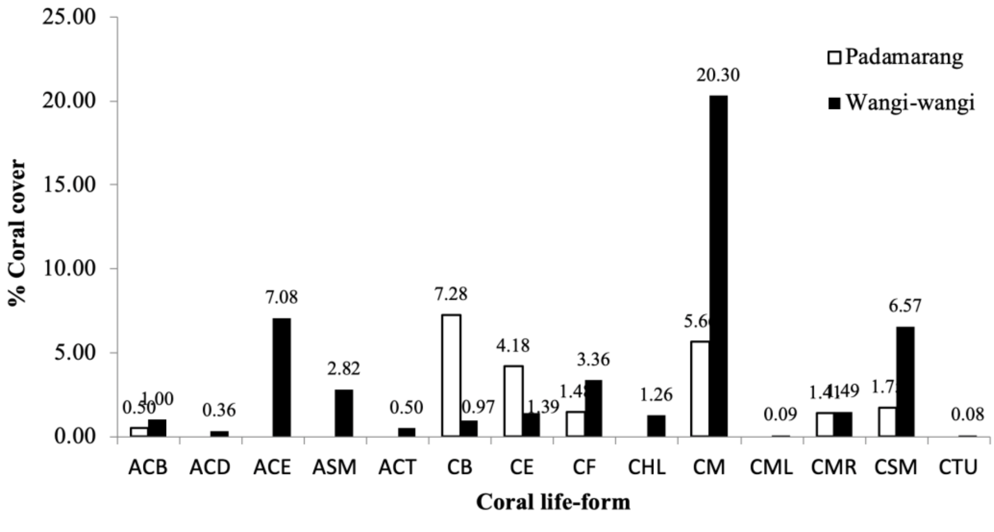

Figure 3. Percentage of live coral cover based on the life-form of coral growth in the waters of Padamarang and Wangi Wangi Islands, Southeast Sulawesi, Indonesia. Note: ACB (acropora branching); ACD (acropora digitata); ACE (acropora encrusting); ASM (acropora submassive); ACT (acrophore tabulate); CB (coral branching); CE (coral encrusting); CF (coral foliose); CHL (coral heliophora); CM (coral fungia); CML (coral meliophora); CMR (coral mushroom); CSM (coral submassive); CTU (coral tubiphora)

Coral disease prevalence

Overall, ten types of coral diseases were identified at the study sites, with Wangi Wangi showing a higher prevalence than Padamarang as depicted in Figures 4 and 5. Additionally, three disease types WS, WBD, and BBD were observed affecting corals in both locations. The Ulcerative White Spot (UWS) disease was exclusive to Wangi Wangi, occurring at a prevalence of about 1%. In total, ten coral genera were affected, with *Porites* sp. being the most common, followed by *Acropora* sp. and *Fungia* sp., as illustrated in Figure 6. A similar phenomenon was observed in *Porites* spp. corals in the waters of Sabu Raijua, East Nusa Tenggara, Indonesia (Johan and Idris 2022), as well as in the Indo-Pacific region (Lozada-misa et al. 2015), where these corals were predominantly affected by diseases and health disturbances, particularly White Syndrome (WS). Coral disease infections occur when there is an interaction between coral as the host, microorganisms as the direct cause of the disease, and environmental factors (Bruno 2015). Environmental conditions at the two study sites also influenced the extent of pathogenic bacterial infections in coral organisms. The relatively high coral density in the waters of Wangi Wangi has facilitated the horizontal transmission of diseases compared to the low-density or patch reef formations in the waters of Padamarang. Additionally, the presence of polyp- and algae-grazing fish may also transfer pathogenic microorganisms to healthy coral colonies, ultimately leading to infection (Chong-Seng et al. 2011). Furthermore, environmental factors such as rising temperatures, increased nutrient levels, and anthropogenic activities by the local community can intensify the virulence of pathogenic bacteria while simultaneously reducing the immunity of coral organisms (Jones et al. 2021).

Moreover, regarding the frequency of coral disease occurrence, WS, UWS, and BBD were found to be more prevalent, particularly affecting *Porites* sp.. The study of coral disease prevalence at Wangi Wangi and Padamarang reveals significant insights into the health of coral ecosystems. Wangi Wangi exhibited a higher overall prevalence of these diseases compared to Padamarang. Coral diseases were first studied in Indonesia, specifically in the waters of Wakatobi by Haapkylä et al. (2007), found a prevalence of 0.57% in 2005, with only two known diseases occurring within the sampling unit, white syndrome (0.42%) and tumors (0.15%), and 0.33% in 2007 (Haapkylä et al. 2009). Meanwhile, Haya et al. (2023), discovered prevalences of 7%, 8%, and 2% in Wanci, Pasijambe, and Padamarang, respectively. Compared to other regions in Indonesia, levels of disease in the Padamarang and Wangi Wangi Islands appear to be low. In Pramuka Island and Pari Island, Kepulauan Seribu found a mean total disease prevalence of 89% and 68% (Johan et al. 2024), and 74.37% in Panjang Island-Jepara (Sabdono et al. 2014).

Wangi Wangi exhibited a higher overall prevalence of these diseases compared to Padamarang, which could suggest varying local stressors (i.e. terrestrial runoff, overfishing, nutrient pollution) or resilience levels between the two locations. Wangi Wangi Island, as a densely populated area, is more likely to experience domestic waste entering its waters, such as household trash, plastic waste, and soap residues. Research by Muhammad et al. (2021) revealed that plastic waste, particularly black plastic, can adversely affect coral health and lead to coral bleaching. The expulsion of Symbiodiniaceae from coral tissues inhibits growth and weakens coral immunity. Stressed corals become more susceptible to diseases or infections by pathogenic microorganisms (parasites) (Mehrotra et al. 2024).

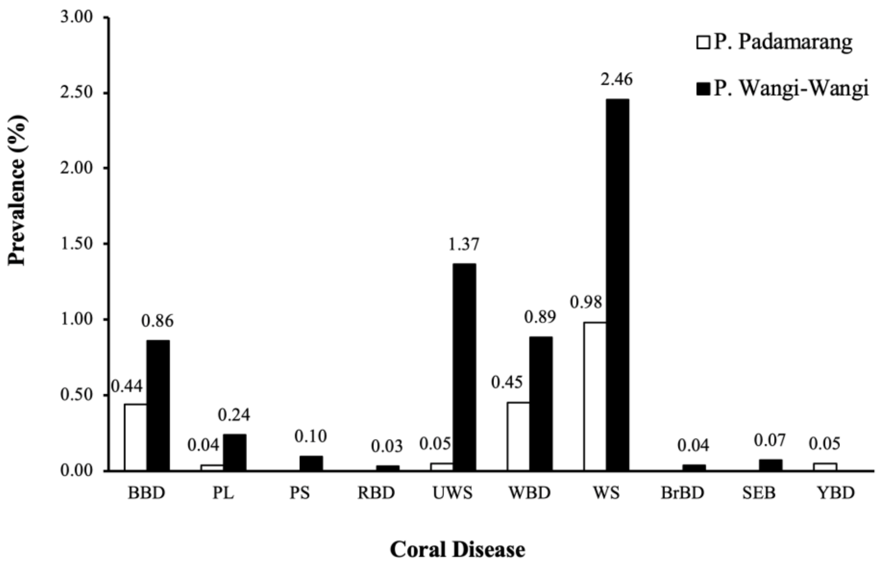

Figure 4. Comparison of the type of disease in Padamarang and Wangi-Wangi Islands, Southeast Sulawesi, Indonesia. Note: Black Band Disease (BBD); Pink Line (PL); Purple Syndrome (PS); Red Band Disease (RBD); Ulcerative White Spot (UWS); White Band Disease (WBD); White Syndrome (WS); Brown Band Disease (BrBD); Skeleton Eroding Band (SEB); Yellow Band Disease (YBD)

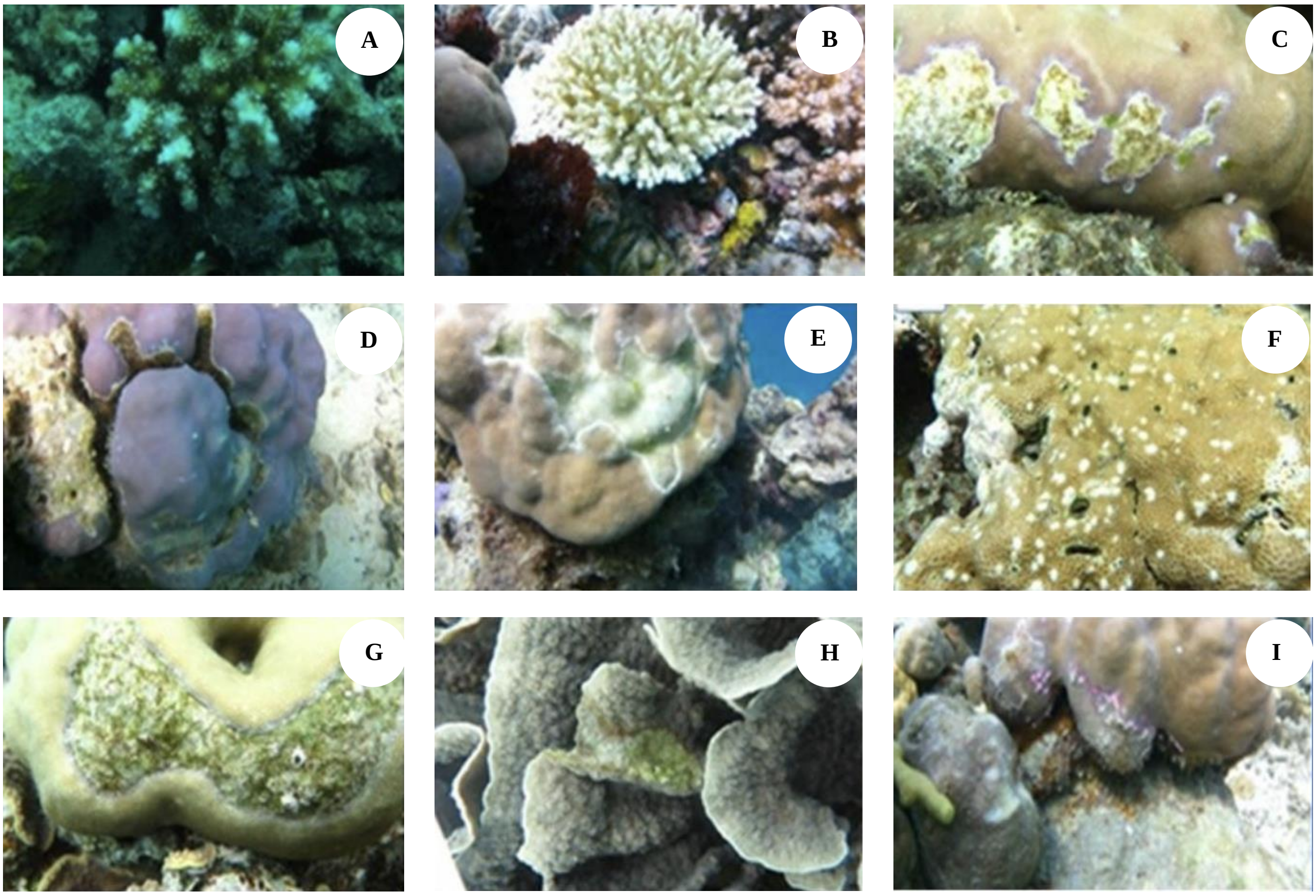

Figure 5. Nine of ten coral diseases recorded in Padamarang and Wangi Wangi Islands, Southeast Sulawesi, Indonesia. Note: A. White Syndrome (WS); B. Bleaching Syndrome (BS); C. Pink Line Syndrome; D. Skeletal eroding band (SEB); E. White Band Disease; F. Ulcerative White Spot; G. Black Band Disease; H. Brown Band Disease; I. Pigmentation Response

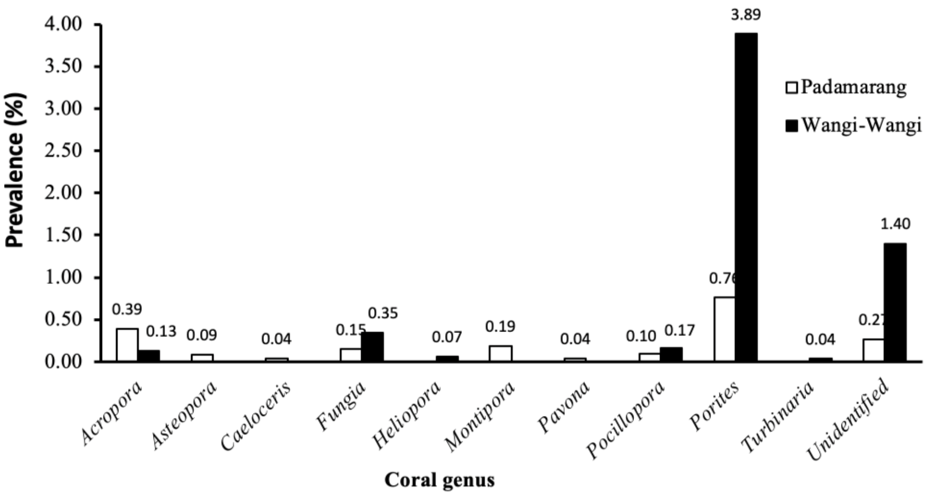

Figure 6. Comparison of disease prevalence of coral genera between Padamarang and Wangi Wangi, Southeast Sulawesi, Indonesia

The fact that White Syndrome (WS), White Band Disease (WBD), and Black Band Disease (BBD) were common to both sites indicates these diseases might be widespread and potentially more aggressive in certain conditions. Some previous studies reported the presence widely of these diseases from the west to the east of Indonesian waters, i.e. Ujung Kulon National Park in Banten (Fahlevy et al. 2019), Belitung (Johan et al. 2015), Kepulauan Seribu (Johan et al. 2024), Banda Neira Conservation Park (Zamani and Januar 2020) and Raja

Ampat, Papua (Subhan et al. 2020). The White Syndrome (WS) disease is recognized as having a high mortality rate (Precht et al. 2016). This disease is often categorized as White Plague types I, II, and III, as well as Stony Coral Tissue Loss Disease (SCTLD). Indications of this disease within a single coral colony include multiple lesions, a high rate of disease spread, and a lack of correlation between the infected host (coral) and coral reef density. These characteristics underscore the need for vigilance regarding its transmission. Furthermore, it has been noted that coral diseases, particularly WS, exhibit varying drivers and types of pathogens depending on the coral species, even within the same location. SCTLD, a type of WS, is particularly aggressive. This disease spreads rapidly within an area (Walker et al. 2021; Ushijima et al. 2023). Unlike bleaching, WS is not directly influenced by temperature increases. Bleaching is more closely associated with elevated temperatures that cause high-stress levels in corals, leading to the expulsion of Symbiodiniaceae algae.

The condition of the aquatic parameters on both islands meets the quality standards for coral growth and health (Table 2). Hence, the higher level of disease prevalence in Wangi Wangi could be addressed by the greater impacts of human activity influences. The number of domestic and international tourists visiting Wangi Wangi Island in 2022, post-COVID-19 pandemic, was recorded at 11,338 individuals (Wakatobi Central Bureau of Statistics 2024). In terms of population, Wangi Wangi Island is the most densely populated among the four main islands in Wakatobi, with a population of 51,162 people (2018), accounting for 53% of the total population in Wakatobi District (Wakatobi Central Bureau of Statistics 2024). Many reviews have documented how anthropogenic stressors both cause coral mortality and alter coral reef communities. Shidqi et al. (2018) revealed the high coral disease prevalence in response of coral to environmental pressure, such as inland pollution from Jakarta Bay. While Isdianto et al. (2024) reported that inorganic marine debris causes detrimental effects on the coral reefs of the Sempu Island Nature Reserve, Malang. The levels of disease on these islands appear to be low. However, the similarity in diversity measures suggests that the species composition and ecological balance between the two sites are relatively comparable, warranting further investigation into the potential impacts of human habitation on reef ecosystems.

Table 2. Parameters of the aquatic environment at the study location

Variable	Padamarang	Wangi Wangi	Quality standards
Temperature (°C)	31.00	29.75	28-30
Salinity (ppm)	34.70	39.35	33-34
pH	8.21	7.87	7-8.5
DO (mg L^{-1})	10.25	12.65	>5
Current velocity (m sec^{-1})	0.14	0.11	
Phosphate (mg L^{-1})	0.05	0.03	0.008
Nitrate (mg L^{-1})	0.10	0.09	0.015

This study concludes that, based on metric diversity, both study locations (Padamarang and Wangi Wangi) exhibit relatively similar values. However, in terms of live coral cover, the waters of Wangi Wangi appear to support a denser overall coral population. This trend is not reflected in coral disease prevalence, where Wangi Wangi shows a higher prevalence compared to Padamarang, likely due to anthropogenic factors. The genus *Porites* demonstrated a particularly high rate of infection, with White Syndrome, White Band Disease, and Black Band Disease being the predominant diseases.

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