Biogenerasi Vol 10 No 3, 2025
**Biogenerasi: Jurnal Pendidikan Biologi**
**Universitas Cokroaminoto Palopo**
https://e-journal.my.id/biogenerasi
e-ISSN 2579-7085

# ANALYSIS OF ACTINOMYCETES ABUNDANCE IN THE RHIZOSPHERE OF MANGROVE ECOSYSTEMS IN SEKOTONG AS A POTENTIAL SOURCE OF BENEFICIAL MICROBES

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**DOI : 10.30605/biogenerasi.v10i3.6701**

**Accepted : 1 Agustus 2025 Approved : 6 September 2025 Published : 8 Agustus 2025**

**Abstract**

The rhizosphere of mangroves is a microhabitat rich in root exudates and organic matter, making it an ideal environment for the growth of *Actinomycetes*. This study aims to analyze the abundance of Actinomycetes in the mangrove rhizosphere at three different locations in Sekotong District, West Lombok: Bagek Kembar, Tanjung Batu, and Buwun Mas. Sampling was conducted using purposive sampling in the dominant root zone at a depth of ±20 cm. Actinomycetes isolation was performed using the surface plate method on SCA medium supplemented with nystatin as an antifungal agent. The results showed that the highest abundance was found in the rhizosphere of *Rhizophora mucronata* at Bagek Kembar with $4.6 \times 10^5$ CFU/g, while the lowest was in Avicennia marina at Tanjung Batu with $1 \times 10^5$ CFU/g. In general, *Rhizophora mucronata* showed higher abundance than *Avicennia marina* in all locations. This difference was influenced by root exudate characteristics, root system structure, and soil physicochemical conditions such as aeration and organic matter content. This study concludes that the rhizosphere of *Rhizophora mucronata* in Bagek Kembar is a more supportive habitat for the growth of *Actinomycetes*. This finding serves as an important basis for further exploration of Actinomycetes isolates from mangroves as potential sources of biocontrol agents and antimicrobial compound producers.

**Keywords :** *Actinomycetes; rhizosphere; mangrove; Sekotong subdistrict*

## INTRODUCTION

Indonesia is a mega biodiversity country with extraordinary marine and terrestrial biological wealth (Rintelen et al., 2017). One of the key ecosystems supporting this diversity is the mangrove forest. Mangroves not only play a role in protecting coastal areas from erosion and tsunamis but also serve as a habitat for unique microorganisms that live in symbiosis with mangrove plants (Palit et al., 2022). This ecosystem holds great potential as a biological resource, including endemic microorganisms that have not been extensively explored. Among these microorganisms, the *Actinomycetes* group holds a significant position due to their remarkable secondary metabolite production capabilities (Sakaroni et al., 2024).

*Actinomycetes* are a group of Gram-positive bacteria known for their ability to produce various bioactive compounds such as antibiotics, antifungals, anticancer agents, and industrial enzymes. Species from the genus Streptomyces, for example, are known to produce more than two-thirds of the antibiotics currently used clinically (Westhoff et al., 2021). The uniqueness of *Actinomycetes* lies in their ability to adapt to various extreme environmental conditions, including marginal ecosystems such as saline soils and flooded areas in mangrove ecosystems (Nazari et al., 2022). This potential makes *Actinomycetes* a primary target in microbial bioprospecting for biotechnology applications.

Previous studies have reported the presence of *Actinomycetes* from various plant rhizosphere habitats. The research by Elshafie & Camele (2022) successfully isolated *Actinomycetes* from soil and plant rhizosphere, and produced bioactive secondary metabolites with antibacterial, antifungal, and antiviral properties. Research by Abdelrahman et al., (2022) showed that *Actinomycetes* from Sudanese soil can inhibit the growth of plant pathogens such as Phytophthora infestans. A similar study by Sengupta et al., (2015) also found that *Actinomycetes* isolates from the Sundarbans mangrove forest produce antimicrobial compounds active against plant pathogens. However, specific exploration of the abundance and distribution of *Actinomycetes* in the rhizosphere of mangrove plants in the West Nusa Tenggara region remains very limited.

This research is important and has novelty value because it focuses on the rhizosphere zone of mangroves in an extreme environment with high salinity that was exposed to heavy metals five years ago. The study of *Actinomycetes* abundance in the rhizosphere of Bagek Kembar mangroves in Sekotong will provide an initial overview of the biological potential of this area in supplying superior isolates for biocontrol purposes and the development of bioactive compounds. With the increasing need for environmentally friendly biocontrol agents in the agriculture and aquaculture sectors, the exploration of potential microbes has become urgent. The results of this study are expected to pave the way for the identification of superior isolates that can be further developed for biotechnology applications.

Analysis of the abundance of *Actinomycetes* from the rhizosphere of plants in the Bagek Kembar mangrove ecosystem, Sekotong, West Lombok, has rarely been conducted to date. Extreme environmental conditions have the potential to serve as unique habitats for *Actinomycetes* (Kumari & Rao, 2023), which have not been extensively explored in terms of abundance. Given the significant potential of *Actinomycetes* in producing bioactive compounds and their role as biocontrol agents, it is important to understand their abundance levels in such environments before exploring their other potentials. The objective of this study is to analyze the abundance of *Actinomycetes* present in the rhizosphere of various mangrove plant species in Sekotong, West Nusa Tenggara. This data will be crucial as a foundation for further exploration of the bioactivity potential of isolates, both as biocontrol agents against plant pathogens and as producers of antimicrobial compounds against human and animal pathogens.

## METHODS

This study was conducted in the coastal area of Sekotong Subdistrict, West Lombok Regency, West Nusa Tenggara. All rhizosphere soil samples were collected directly from beneath the mangrove vegetation that dominates each location. After collection, the samples were brought to the laboratory for further analysis. The isolation of *Actinomycetes*, abundance counting, and colony distribution analysis were carried out at the Biology Education Laboratory, Faculty of Teacher Training and Education (FKIP), Mataram University, which is equipped with basic microbiology equipment for research on the isolation and identification of environmental microbes.

Rhizosphere soil sampling was conducted at three different locations within the mangrove ecosystem, namely Bagek Kembar, Tanjung Batu, and Buwun Mas in Sekotong District, West Lombok Regency, West Nusa Tenggara. Sampling points were determined using purposive sampling, based on the presence of naturally growing mangrove vegetation with relatively high coverage at each location. According to Dana (2020), purposive sampling is a sampling technique used when researchers already have target individuals with characteristics that match the research.

The sampling area was determined using the quadrant method. Quadrants in mangrove rhizosphere sampling can be determined by drawing lines on each transect and creating quadrants of a certain size (Valenciana et al., 2025). The quadrants are adjusted to the habitus of mangrove plants, namely: plot size of 10 × 10 m for main mangrove trees (*Avicennia, Rhizophora, Sonneratia*, and others). At each location, four quadrant plots measuring 20 × 20 m are systematically created following the tidal line (mangrove zoning), covering the front (near shore), middle, and back (landward) sections. The rhizosphere is collected from the roots of these plants using a sterile spatula at a depth of ±20 cm (Ye et al., 2023). At each plot, rhizosphere soil samples were collected at four evenly distributed points around the root system of the dominant plant. All samples were then placed in sterile plastic bags and stored in a cooler for subsequent analysis in the laboratory.

The isolation process of *Actinomycetes* was modified from the steps described by Kumar et al., (2016) from rhizosphere soil samples using the Spread Plate method. Five grams of rhizosphere soil were placed in an Erlenmeyer flask containing 45 ml of sterile distilled water. The soil suspension was vortexed and serially diluted. One milliliter of the suspension was taken and added to a reaction tube containing sterile solution to produce a $10^{-1}$ dilution, then vortexed. The dilution process was continued up to $10^{-3}$. Each dilution ($10^{-1}$ to $10^{-3}$) was taken in 100 µl aliquots and aseptically inoculated into Petri dishes containing SCA (Starch Casein Agar) medium supplemented with Nystatin or Nalidixic acid at a concentration of 1.25 ppm to inhibit the growth of fungi and Gram-negative bacteria. The suspension on the medium was then spread using an L-shaped spreader and incubated at 30°C for 7 days in an incubator. Colonies with characteristic *Actinomycetes* morphology, such as dry, filamentous, and mold-like colonies, were visually observed. Colonies showing different morphology were selected for further purification through subculturing on SCA medium until pure isolates were obtained.

The abundance of *Actinomycetes* in each plant rhizosphere was analyzed by counting using the plate count method. The number of colonies was expressed in Colony Forming Units (CFU) and calculated using the formula: CFUgr-1 = number of *Actinomycetes* colonies × 1/dilution factor (Clark, 2016).

## RESULTS AND DISCUSSION

### Description of Research Location

The vegetation components of the mangrove ecosystem at three observation sites, namely Bagek Kembar, Tanjung Batu, and Buwun Mas in Sekotong District, West Lombok Regency, show variations in species and vegetation structure that are characteristic of tropical coastal ecosystems (Figure 1). Based on the results of vegetation inventory, there are a total of 4 families with 9 major mangrove species and 1 minor mangrove species. The major mangrove species include *Avicennia alba*, *Avicennia marina*, *Bruguiera gymnorrhiza*, *Ceriops tagal*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Rhizophora stylosa*, *Sonneratia alba*, and *Sonneratia caseolaris*. The minor mangrove species is *Excoecaria agallocha* (Hidayat et al., 2024)

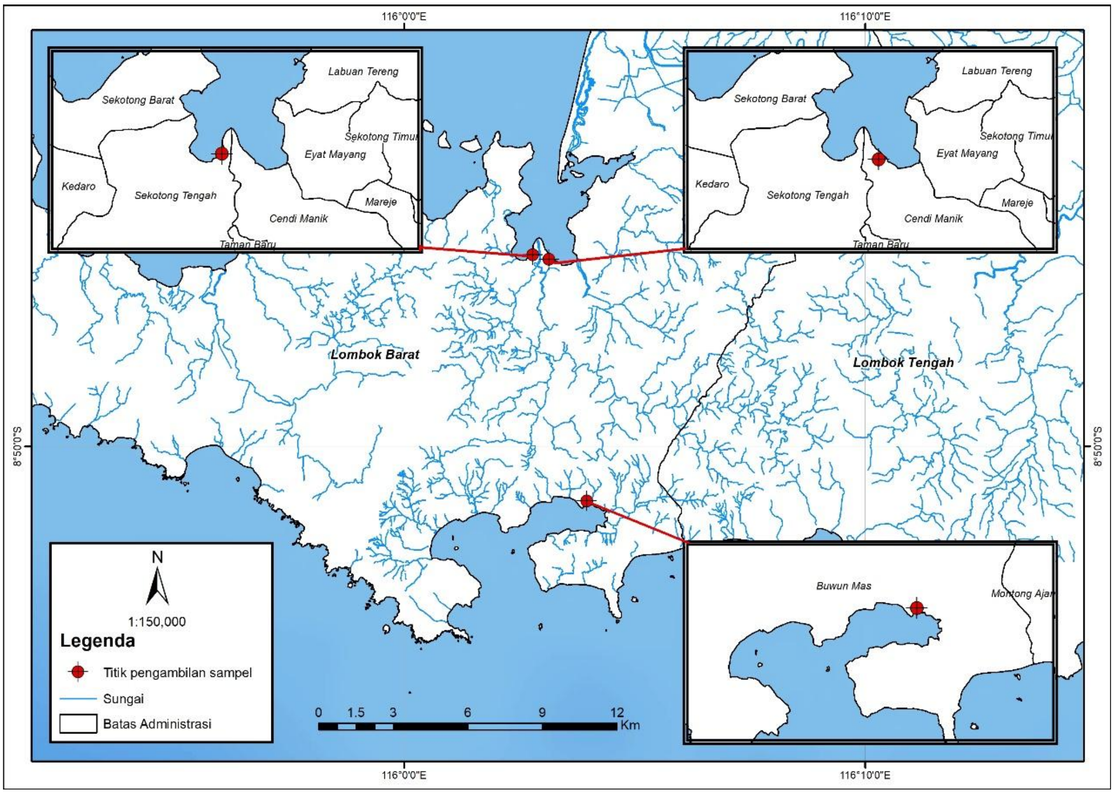

Figure 1. Research location

Some of the dominant species found at all three locations and used as sampling points for rhizosphere soil include *Rhizophora mucronata* and *Avicennia marina*. These species were selected because they have a wide distribution, complex root systems, and make a significant contribution to the formation of microbial rhizosphere habitats in the intertidal zone of mangrove (Qudraty et al., 2023).

The vegetation in all three locations showed a layered canopy structure, ranging from mature trees to saplings (Maulidah & Zakiyah, 2023). Plants with respiratory root systems (pneumatophores or prop roots) provide microhabitats that are highly suitable for the growth and activity of microorganisms such as *Actinomycetes*(Pascale et al., 2020). The relatively dense vegetation structure and moist, organic-rich substrate conditions make the rhizosphere zones at these three locations potential ecosystems for superior microorganisms. Research by Baskaran et al., (2023) shows that microorganisms found in the mangrove rhizosphere include *Firmicutes*, *Proteobacteria*, *Actinomycetes*, *Bacteroidetes*, and *Halomonas*, with 38 genera and 105 species. The various types of bacteria that grow in the mangrove rhizosphere are also influenced by their ability to adapt to various abiotic environmental factors.

**Environmental Parameters**

This study also evaluated the environmental conditions of the mangrove rhizosphere soil at three locations in Sekotong District, namely Bagek Kembar, Tanjung Batu, and Buwun Mas. The environmental parameters measured included pH, moisture, salinity, and soil temperature. These are important factors that can affect the growth and abundance of *Actinomycetes*.

Table 1. Environmental Parameters

| Num | Location | Parameter lingkungan | | | |
|---|---|---|---|---|---|
| | | pH | Humidity | Salinity | Temp ($^{o}$C) |
| 1 | Bagek Kembar, Cendi Manik Village | 6,4 | 59,12% | 11,9% | 30,2 |
| 2 | Tanjung Batu, Sekotong Tengah Village | 5,9 | 61,56% | 12,6% | 30,5 |
| 3 | Buwun Mas Village | 6,1 | 58,87% | 12,8% | 30 |

Primary data sources processed in 2025

The pH value of the soil at the three locations ranged from 5.8 to 6.2, which is classified as slightly acidic to neutral. The Bagek Kembar site showed the highest pH

(6.4), while Tanjung Batu had the lowest pH (5.9). These pH values are suitable for the growth of *Actinomycetes*, which generally grow optimally within a pH range of 6–8, although some species are tolerant of lower pH levels (Kavitha et al., 2023). According to Li et al., (2024), pH affects nutrient availability and enzyme activity involved in microbial metabolism, including the production of secondary metabolites by *Actinomycetes*.

The highest humidity was recorded in Tanjung Batu (62.56%), and the lowest in Buwun Mas (61.56%), followed by Bagek Kembar (59.12%), and in the Buwun Mas Vllage (58.87%). In general, all three locations showed moderate humidity, which is characteristic of mangrove ecosystems. According to Dalengkade (2020) humidity in mangrove areas typically rises at night, peaking in the early morning (up to 85.5%), and decreases during the day due to sunlight and evaporation. Areas with dense mangrove canopy maintain higher humidity compared to edges or open areas, as the canopy reduces evaporation and sun exposure. Research by Nauanova et al., (2018), in northern Kazakhstan confirmed that *Actinomycetes* are most abundant and active in soils with moderate to high moisture content, but not in waterlogged or dry soils. Based on the results of the research, *Actinomycetes*, especially Streptomyces, thrive in humid, air-filled soil pores. Growth is significantly reduced in waterlogged (saturated) soils and is also limited in very dry conditions. Spores can survive dry periods, but active growth requires moisture. Moisture is a crucial factor in supporting soil microbial growth. Groth & Saiz-Jimenez (1999) also emphasize that *Actinomycetes* tend to grow well in moderate to high moisture conditions, but excessive moisture can inhibit their sporulation. Moisture conditions above 50%, as found at the study site, are quite ideal for supporting the development of actinomycete communities in mangrove rhizosphere soil rich in organic matter and root exudates. However, soil can sometimes remain waterlogged for longer than usual, making *Actinomycetes* uniquely capable of adapting to such conditions.

Based on Table 1, salinity values at the three study sites show some variation. The Bagek Kembar site has a salinity of 11.9‰, Tanjung Batu 12.4‰, and Buwun Mas 12.6‰. These three values fall into the moderate salinity category for coastal mangrove ecosystems, with Buwun Mas having the highest salinity level. Variations in salinity between locations are influenced by several environmental factors such as distance from river mouths, tidal fluctuations, and the availability of freshwater entering the mangrove area (Smyth & Elliott, 2019). Salinity is an important parameter that can influence soil microbial communities, including *Actinomycetes*, as most microbial species have different tolerances to salt concentrations.

Higher salinity levels, such as those found at the Buwun Mas site (12.6‰), can inhibit the growth of certain salt-sensitive *Actinomycetes*, but conversely, they can provide natural selection for halotolerant and halophilic microorganisms, such as certain species of *Actinomycetes* from the genera *Streptomyces* and *Micromonospora* (Sharma et al., 2022). Therefore, locations with higher salinity levels are likely to be potential sources of unique *Actinomycete* isolates capable of producing bioactive compounds under osmotic stress. This finding is also consistent with research by Abidin et al., (2020), who stated that extreme environments such as mangrove ecosystems with salinity fluctuations ranging from moderate to high can serve as hotspots for the diversity of adaptive marine *Actinomycetes* and have the potential as sources of new antibiotics.

**The Abundance of *Actinomycetes***

The rhizosphere is a highly microbiologically active region due to root exudates, such as amino acids, sugars, and phenolic compounds, which support the growth of microorganisms including *Actinomycetes*. Variations in mangrove tree species affect the quality and quantity of these exudates.

Tabel 2. Abundance of *Actinomycetes*

| Number | Sampling Point | Mangrove Rhizosphere | Abundance (CFU g) |
|---|---|---|---|
| 1 | Bagek Kembar | *Rhizophora mucronata* | 4,6 x $10^5$ |

| | | | |
|---|---|---|---|
| | | *Avicennia marina* | 3,2 x $10^5$ |
| 2 | Tanjung Batu | *Rhizophora mucronata* | 2,5 x $10^5$ |
| | | *Avicennia marina* | 1 x $10^5$ |
| 3 | Buwun Mas | *Rhizophora mucronata* | 2 x $10^5$ |
| | | *Avicennia marina* | 1,2 x $10^5$ |

Primary data sources processed in 2025

Table 2 shows that the abundance of *Actinomycetes* (in CFU/g) varies depending on the type of mangrove and sampling location. A general pattern observed is that the rhizosphere of *Rhizophora mucronata* shows higher abundance of *Actinomycetes* compared to *Avicennia marina* at all three sampling locations. The highest value was found in the rhizosphere of *Rhizophora mucronata* at Bagek Kembar (4.6 × $10^5$ CFU/g), while the lowest value was found in *Avicennia marina* at Tanjung Batu (1 × $10^5$ CFU/g).

The results of this study indicate that the rhizosphere of mangroves, particularly *Rhizophora mucronata*, supports a higher abundance of *Actinomycetes* compared to *Avicennia marina*. This is likely related to differences in root exudates, root structure, and the microhabitat conditions formed around the roots of each mangrove species. The type and composition of root exudates released by plant roots play a crucial role in shaping the abundance and diversity of soil microbial communities. Different plant species, even at different growth stages, can produce distinct exudate profiles, which selectively stimulate or suppress specific bacterial and fungal groups in the rhizosphere, thereby influencing nutrient cycling and plant health (Zhao et al., 2020; Dhungana et al., 2022).

The root exudate of *Rhizophora mucronata* contains organic compounds such as polysaccharides, amino acids, and more complex organic acids than *Avicennia marina* (Hastuti et al., 2024). Additionally, anatomical differences in roots and chemical defenses, such as higher concentrations of polyphenols, tannins, and lignin in *R. mucronata*, may contribute to its more complex exudate profile (Naidoo & Naidoo, 2018). This exudate enhances the availability of carbon and nitrogen required by *Actinomycetes*, a group of filamentous bacteria known to grow in environments with complex organic matter.

The root system of *Rhizophora* consists of stilt roots with prominent lenticels and internal air spaces, which allow oxygen to reach the submerged roots. This morphology provides better aeration structure in sediments compared to *Avicennia*, which uses pneumatophores (McKee, 1996). Good aeration allows for higher microbial metabolic activity, including *Actinomycetes*, which are facultative aerobes.

Bagek Kembar site shows the highest values for both mangrove species. This indicates that, in addition to mangrove species, local environmental factors such as organic matter content, soil texture, salinity, and moisture play crucial roles in shaping soil microbial populations. High organic carbon levels generally support greater microbial abundance and activity, but the relationship is influenced by climate and soil type, with warmer climates often enhancing microbial growth efficiency even at lower organic carbon levels (Williams et al., 2025; Waldrop et al., 2017). This area is thought to have rhizosphere quality that is more supportive of *Actinomycetes* growth than Tanjung Batu and Buwun Mas.

*Actinomycetes* are known as producers of natural antibiotics and enzymes that degrade organic matter, which are very important for mangrove ecosystems. Their high presence in the rhizosphere of *Rhizophora mucronata* reinforces the potential for exploring endemic microbes from this ecosystem as a source of new antimicrobial agents and natural biocontrol.

## CONCLUSIONS AND SUGGESTIONS

This study shows that the rhizosphere of mangrove plants in the Sekotong area, West Lombok, has a fairly high abundance of Actinomycetes, particularly in Rhizophora mucronata compared to Avicennia marina. The Bagek Kembar location shows the highest abundance, indicating that environmental factors such as neutral pH, moderate humidity, and high organic matter content also support the growth of Actinomycetes. Differences in root structure and root exudate composition between mangrove species influence the number and distribution of Actinomycetes colonies in the rhizosphere. These findings confirm that the rhizosphere of Rhizophora mucronata is a potential habitat for exploring potential Actinomycetes isolates that can be developed as biocontrol agents and producers of bioactive compounds in biotechnology applications. Further investigation of the bioactivity of Actinomycetes isolates against plant pathogens and human pathogenic microorganisms is needed to evaluate the direct application potential of the isolates.

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