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# ASSESSING MANGROVE HEALTHINESS LEVEL OF MANGROVES ALONG THE OESAPA COASTLINE USING THE MONMANG APP

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## ABSTRACT

Despite being considered one of the most important ecosystems on earth, mangrove forests have been threatened by humans, which can lead to global mangrove loss. Therefore, the restoration of mangroves on both a global and a certain spatial scale is required. One of the mangroves that benefit local communities ecologically is occurring along the Oseapa coastline in Kupang, East Nusa Tenggara Province. In order to successfully restore degraded mangroves, a comprehensive assessment of their healthiness level is necessary. Hence, the MonMang Android-based application developed by BRIN can be used to collect the data within observation transects and plots and then analyze the healthiness level. The Oesapa mangrove forest is a habtat for 8 mangrove species belonging to 5 families. They are *Avicennia alba*, *Avicennia marina*, *Ceriops tagal*, *Lumnitzera racemosa*, *Sonneratia alba*, *Rhizopora mucronata*, *Rhizopora apiculata*, and *Xylocarpus sp.* The MonMang application reveals that the overall mangrove healthiness is at Moderate level. In addition, we found that Site 2 has the lowest Mangrove Health Index (MHI) value, with an average of 35.00-65.00. This indicates that the reforestation is strongly suggested in this area. It can be prioritized for restoration efforts to improve healthiness and mangrove cover. The spatial re-plantation also needs to be conducted in other locations within Oesapa mangrove forest which possess Moderate level of mangrove healthiness. Moreover, stump occurrence and garbage coverage vary across the observation sites. Site 2 has the highest proportion of stump occurrence, possibly due to past mangrove dieback. Garbage coverage varies across the sites, with plots closest to seaward having the lowest coverage and those close to settlements having the highest. These findings highlight the need for further restoration efforts to maintain the sustainability of mangrove forest along the Oesapa coastline.

**Keywords**: Mangrove healthiness; MonMang App; Mangrove Health Index; restoration

## 1. INTRODUCTION

Despite human threats, mangrove forests are regarded as one of the planet's most significant forest ecosystems (Friess et al., 2019). Mangroves offer a range of essential ecosystem services, including supplying, regulating, supporting, and cultural functions (de Souza Queiroz et al., 2017). They provide shelters and nursery grounds for fish and various invertebrate species (Friess et al., 2019). They also protect coastal environment as a strong barries from huge waves and storm and prevent coastal abrasion (Gilman et al., 2008). Numerous wildlife species, including humans, have depended on them for their survival due to their distinct ecological functions.

One of the world's largest mangrove forests, Indonesia, has great potential for achieving the Sustainable Development Goals. Furthermore, in the context of the global scale, they may offer a way to counteract climate change and lessen its negative effects (Chow, 2018; Gilman et al., 2008). In a global context, mangroves in Indonesia can also contribute to the mitigation efforts of climate changes (Soimin, 2018).

Given that mangrove forests cover much of the Indonesian archipelago's coastline, they can also provide a localized

solution for a number of newly emerging problems, including ecological, social-economic, and environmental ones (Arifanti et al., 2022; Sofian et al., 2019). Mangrove forests can be used by local communities in a variety of sustainable ways. Mangroves can generate revenue for the community by hosting eco-tourist events. Using mangrove fruits (propagule) to produce coffee or mangrove-fruit-based snacks, or soaps is another enormous potential (Sabana, 2015; Sulistyawati et al., 2021).

In order to assess the level of healthiness of mangroves, the MonMang Android-based Application developed by BRIN can be used (Fakhrurrozi et al., 2024). It attempts to provide comprehensive assessment on mangrove healthiness level with a form of mangrove health index (MHI), namely Poor, Moderate, and Excellent. The assessment results can also be used as a scientific baseline to conduct reforestation efforts on mangrove forests so that successful restoration can be achieved.

One mangrove forest occurring in the coast of Kupang is the Oesapa mangrove forest. The mangroves have been a long time providing numerous ecosystem services for local communities. It protects the coast from heavy waves and provide habitat for many consumable fish and other biota. The mangroves are also a popular ecotourism in Kupang. Therefore, conducting research prior to restoration in Oesapa mangrove forest is important as various factors need to be understood to achieve successful restoration. More importantly, focusing certain area as re-plantation area is less costly. Further, it can also determine what suitable mangrove species to be re-planted.

## 2. METHODS

### 2.1 Research Site

The Oesapa mangrove forest in Kupang was the site of a scientific assessment of the mangrove healthiness level. The mangrove forest is located near Kupang Town, the provincial seat of East Nusa Tenggara Province, on its northern shore (Figure 1). The size of the mangrove forest is about 17.000 $m^2$ or 17 ha (Penkari et al., 2009).

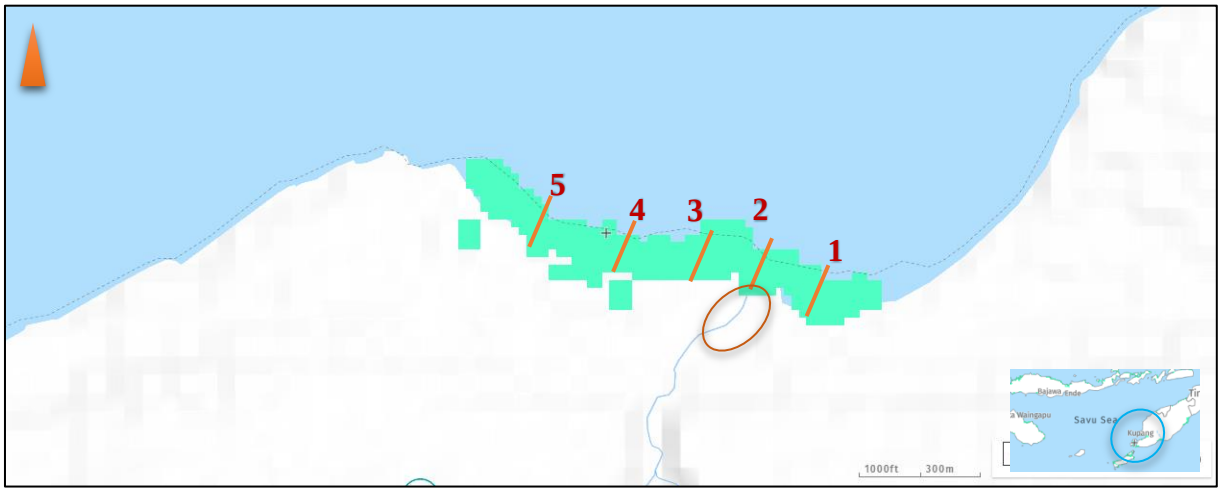


Figure 1. Depicting the Oesapa mangrove forest map on northern coast of Kupang (lat, lon: -10.14389, 123.63483), an area belongs to the Marine Natural Tourism Park of Kupang Bay. The light green colour indicates the coverage of mangrove forest. Red circle indicates the estuary of Liliba River.

### 2.2 Data Collection

We employed the MonMang Android Application in the fieldwork during low tide periods. To make sure the software functioned properly on the data collectors' Android smartphones; it was first installed on the device and tested. We then gathered data on specific parameters along a transect line that went from landward to seaward. We gathered data throughout the transect

within plot squares measuring 10 x 10 m for trees, 5 x 5 m for saplings, and 2 x 2 m for seedlings and substrate garbage coverage (Figure 2).

Five observation transects were set up to traverse the mangroves from landward to seaward direction. The length of transect is comparable to that of mangroves approximately 100 m to 150 m. The transect features are presented in Figure 2.

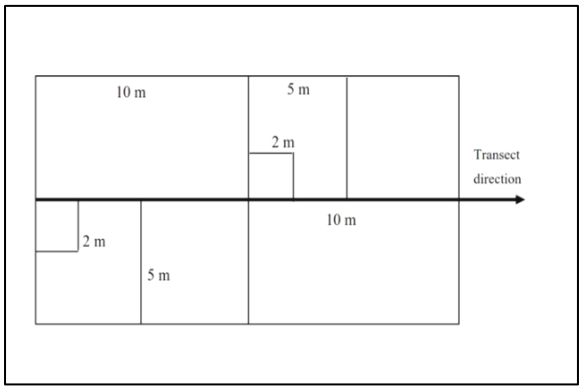


Figure 2. Depicting transect and plot designs on the study sites. The plot squares of10 x 10 m for trees, 5 x 5 m for saplings, and 2 x 2 m for seedlings and substrate garbage coverage.

**2.3 Data Analysis**

The Level of mangrove healthiness was assessed using the MonMang Android Application. The application was developed by BRIN and is based on AI and Android. The healthiness level is represented in Mangrove Health Index (MHI) and then translated into three levels, namely Poor, Moderate, and Excellent.

## 3. RESULTS AND DISCUSSION

### 3.1 Mangrove Composition of Oesapa Mangrove Forest and Its Conservation Status

The mangrove forest along the coast of Kupang is a part of the mangrove ecosystem on the Marine Natural Tourism Park (Taman Wisata Alam Laut) of Kupang Bay, which was officially established by the Minister of Forestry's Decree No. 18/Kpts-II/1993. Nonetheless, the existence of the mangrove forest along the Oesapa coastline was put in jeopardy due to the Kupang development and the increasing coastal population (Matatula, 2010). The restoration initiatives have been implemented between 2002 and 2007 but have not produced positive outcomes.

An assessment of the mangrove healthiness level along the Oesapa coastline has never been conducted since the unavailability of scientific evidence published in academic references. This assessment is significant as a preliminary study prior to mangrove restoration. Mangrove restoration itself is crucial to maintaining mangrove coverage across the globe (Kathiresan & Bingham, 2001). Therefore, mangrove forests in Oesapa require restoration efforts to maintain their sustainability.

It is recorded that 8 mangrove species belonging to 5 families occur in the Oesapa mangrove forest. The species are *Avicennia alba*, *Avicennia marina*, *Ceriops tagal*, *Lumnitzera racemosa*, *Sonneratia alba*, *Rhizopora mucronata*, *Rhizopora apiculata*, and *Xylocarpus sp.* Based on IUCN, the conservation status of those species is Least Concern (LC), Near Threatened (NT), and No Conservation Status Available only for *Lumnitzera racemosa*. The occurrence of mangrove species across the observation sites varies as a result of several environmental factors. This can be due to substrate composition, salinity, and pH (Kathiresan & Bingham, 2001; Lugo & Snedaker, 1974). Different species possess distinct environmental conditions.

Table 1. Depicting observed mangrove species in Oesapa mangrove forest and its conservation status.

| No | Species | Family | Sites 1 | Sites 2 | Sites 3 | Sites 4 | Sites 5 | IUCN Status |
|---|---|---|---|---|---|---|---|---|
| 1 | *Avicennia alba* | *Avicenniaceae* | + | - | - | + | - | Least Concern (LC) |
| 2 | *Avicennia marina* | *Avicenniaceae* | - | + | + | + | - | Least Concern (LC) |

| No | Species | Family | Sites 1 | Sites 2 | Sites 3 | Sites 4 | Sites 5 | IUCN Status |
|---|---|---|---|---|---|---|---|---|
| 3 | *Ceriops tagal* | *Rhizoporaceae* | + | + | + | + | - | Least Concern (LC) |
| 4 | *Lumnitzera racemose* | *Combretaceae* | + | + | + | - | - | No Status Available (NA) |
| 5 | *Sonneratia alba* | *Sonneratiaceae* | + | - | + | + | + | Least Concern (LC) |
| 6 | *Rhizopora mucronata* | *Rhizoporaceae* | + | - | + | + | + | Near Threatened (NT) |
| 7 | *Rhizopora apiculate* | *Rhizoporaceae* | + | - | - | + | + | Least Concern (LC) |
| 8 | *Xylocarpus sp.* | *Meliaceae* | + | - | - | + | + | Least Concern (LC) |

### 3.2 Mangrove Health Index (MHI)

The MonMang Android Application unveils the MHI values of all plots across the observation sites (Figure 3). It is noticeable that the MHI value of Site 2 is the lowest. All plots in Site 2 reveal the lowest MHI value compared with other sites. The healthiness level of mangrove in Site 2 is poor (MHI < 34.50), while other sites unveil moderate to excellent levels with MHI > 35.00.

On average, the healthiness level of mangrove is at a moderate level, as the majority of lots show MHI values of 35.00 – 65.00. Only three plots had MHI values greater than 65.00, indicating an excellent level of healthiness.

With the moderate level of mangrove healthiness, the Oesapa mangrove forest can be prioritized to conduct restoration efforts to improve the healthiness level and mangrove cover. It is also possible to preferably conduct restoration efforts at Site 2, as it has a poor level.

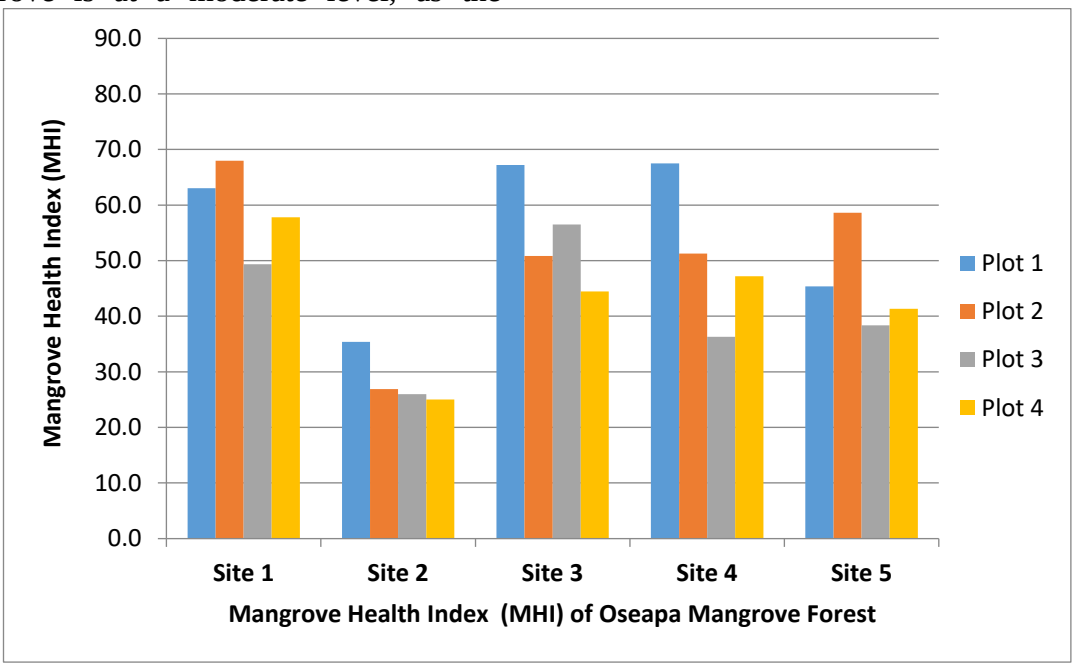


Figure 3. Depicting the MHI of Oesapa mangrove forest across five observation sites. It is noticeable that MHI value of Site 2 is the lowest. All plots in Sites 2 unveil the lowest MHI value compared with other Sites. The healthiness level of mangrove in Site 2 is Poor Level (MHI < 34.50, while other sites unveil Moderate to Excellent level with MHI > 35.00.

### 3.3 Stump Occurrence and Garbage Coverage

Stump occurrence and garbage coverage are two other parameters in the MonMang Android Application to analyze. Figure 4 highlights that Site 2 unveils the highest proportion of stump occurrence, while Site 1 the lowest proportion of stump occurrence. Site 3, 4, and 5 unveil average proportion of stump occurrence ranging from 11% to 60% and varies across the plots. In Site 2, the very low MHI value is attributed to the high stump occurrence. All plots in Site 2 unveil stump occurrence from

78%-88%. In this site, a mangrove dieback phenomenon occurred in the past (Figure 6a). This is possibly caused by dramatic changes in the environment, including substrate types and chemical properties of the substrate. Matatula et al., (2019) suspected that this phenomenon was the cause of coastal development in which the concrete structure was built to protect the settlement from huge waves. This topographical change creates dynamic within water and soil parameters, including salinity, pH, fresh water intake, bulk density, mud suspension, high and low tide pattern, sand composition on substrate (Kathiresan & Bingham, 2001).

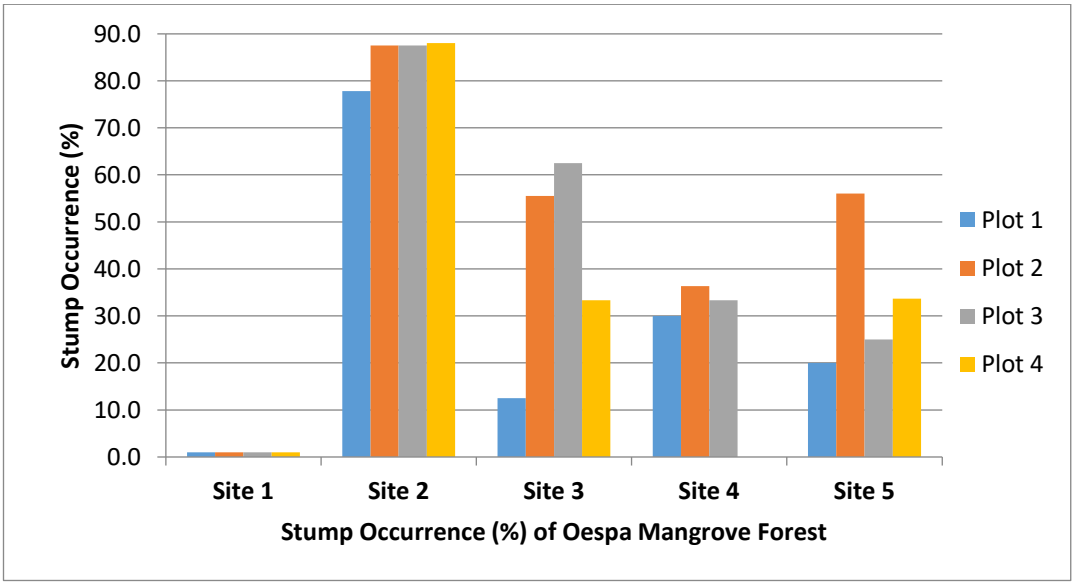


Figure 4. Depicting the stump occurrence across the observation sites. Site 2 unveils the highest stump occurrence, while Site 1 unveils the lowest stump occurrence. Site 3, 4, and 5 unveil average proportion of stump occurrence.

The mangrove dieback can also possibly occur due to freshwater runoff from the Liliba River. This runoff, during rainy season, brings not only fresh water but also sediment. As a result, excessive amount of sediment and fresh water trapped on the estuary and therefore alter water and substrate dynamics. Matatula et al., (2019) found that water salinity in the estuary of the Liliba River is lower than surrounding mangrove that is approximately 17%-19% with higher total suspended solid. This salinity is lower than the latest findings that the salinity is approximately 29%-33% (Radja et al., 2023). Periodic fresh water and sediments input benefits mangroves because it nourishes mangroves. However, detrimental and long-lasting effects can emerge as a result of major fresh water flooding (Adams & Human, 2016; Mohammed et al., 2014).

Garbage coverage on the mangrove forest floor varies across the observation sites (Figure 5). It is noticeable that Plot 4 closest to seaward unveil the lowest garbage coverage, while the plots that close to settlement possess high proportion of garbage coverage. This pattern indicates that the people might contribute because they litter to the mangroves. This can also indicate that mangroves close to seaward are frequently inundated by waves therefore it moves the garbage, either to the water of backwards mangroves and then trapped due to dense rooting systems, lower branching, and penumatophores. The rooting system and branching that traps the garbage can be seen on Figure 6b. The mangroves adjacent to community settlements on landward direction can also be seen on Figure 6c.

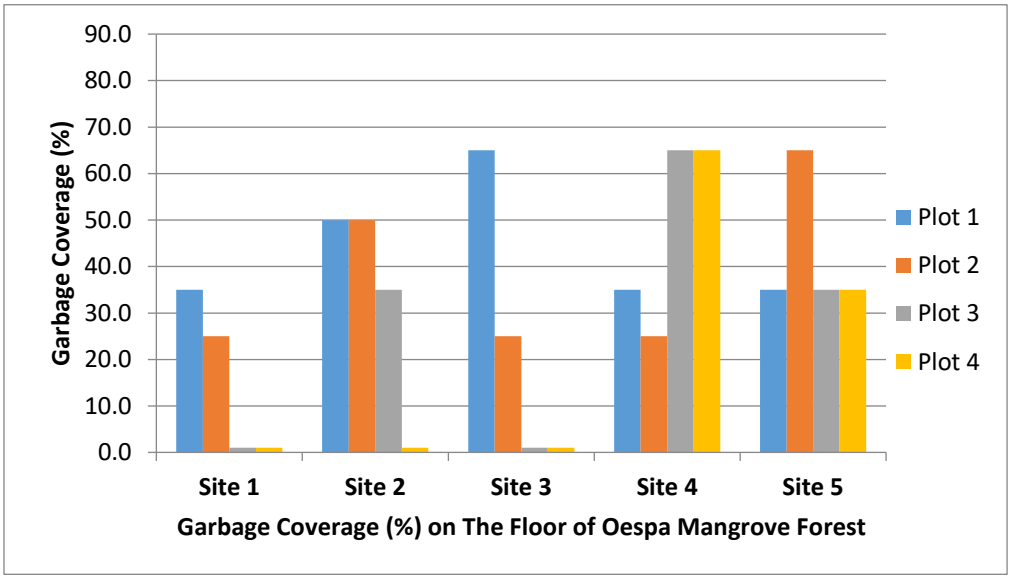


Figure 5. . Depicting the garbage coverage on the mangrove forest floor across the observation sites. Plot 4, the closest to seaward, unveils the lowest garbage coverage, except in Site 4.

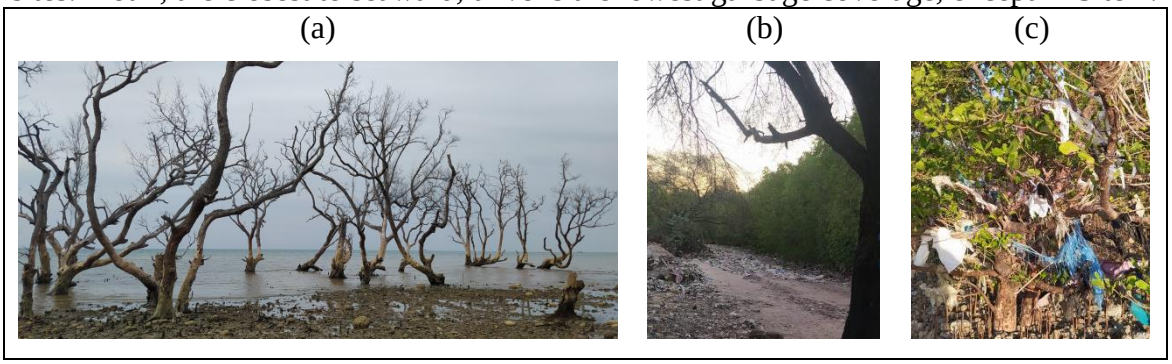


Figure 6. a. Mangrove dieback along the estuary of Liliba River. b. Garbage coverage on the forest floor closed by community settlements. c. Various plastic garbage trapped by roots and branching system of mangroves.

## 4. CONCLUSION

An important aspect of mangrove restoration is a scientific research. In order to successfully restore degraded mangroves, a comprehensive assessment of their health level is necessary. Hence, the MonMang Android-based application developed by BRIN can be used to collect the data within observation transects and plots. This is also suggested in Oesapa mangrove forest. The mangrove forest is habitated by 8 mangrove species from 5 families. They are *Avicennia alba, Avicennia marina, Ceriops tagal, Lumnitzera racemosa, Sonneratia alba, Rhizopora mucronata, Rhizopora apiculata,* and *Xylocarpus sp.* The MonMang application reveal that the overall mangrove healthiness is at Moderate Level. In addition, we found that Site 2 has the lowest Mangrove Health Index (MHI) value, with an average of 35.00 - 65.00. This indicates that the reforestation is strongly suggested in this area. It can be prioritized for restoration efforts to improve healthiness and mangrove cover. The spatial re-plantation also needs to be conducted in other locations within Oesapa mangrove forest which possess Moderate Level of mangrove healthiness. Moreover, stump occurrence and garbage coverage vary across the observation sites. Site 2 has the highest proportion of stump occurrence, possibly due to past mangrove dieback. Garbage coverage varies across the sites, with plots closest to seaward having the lowest coverage and those close to settlements having the highest. These findings highlight the need for further restoration efforts to maintain the

sustainability of mangroves along the Oesapa coastline.

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