Environmental Observation and Potency of Lindur Fruit 
(*Bruguiera gymnorrhiza*) as Alternative Food Substance

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Abstract: The purpose of this paper is to know the content of heavy metal Pb in water, sediment and lindur (*Bruguiera gymnorrhiza*) at Ecotourism Mangrove Wonorejo Surabaya. The research methodology of this paper using descriptive quantitative method and with use water, sediment and lindur (*Bruguiera gymnorrhiza*) as the sample that taken at station I, II, III with 3 replications. Physical parameter including temperature, pH, and salinity were tested directly in the field, while the heavy metal content of Pb was tested using AAS method. Finding of the research showed that water, sediments and lindur (*Bruguiera gymnorrhiza*) in Ecotourism Mangrove Wonorejo has been contaminated by heavy metals Pb. Originality of this research explain that the average content of heavy metal Pb in water at station I 0.92 mg/L, station II 0.86 mg/L, and station III 1.08 mg/L, heavy metal concentration of Pb in water has exceeded the limit of the quality standard of water according to Decision of Environment Minister Number 51 of 2004 that is 0.05mg/L. The content of heavy metal Pb in sediments at station I 2.69 mg/Kg, station II 2.92 mg/Kg, and at station III 2.98 mg/Kg, heavy metal Pb is still below the limit according to the government regulation of Indonesia Number 85 of 1999 is 5.0 mg/Kg. The average content of heavy metal Pb on lindur (*Bruguiera gymnorrhiza*) are at station I 0.13 mg/Kg (epidermis layer 0.10 mg/Kg, mesodermis 0.04 mg/Kg, and endodermis 0.26 mg/Kg), station II 0.15 mg/Kg (epidermis 0.13 mg/Kg, mesodermis 0.05 mg/Kg and endodermis 0.27 mg/Kg), station III 0.16 mg/Kg (epidermis layer 0.14 mg/Kg, mesodermis 0.06 mg/Kg and endodermis 0.29 mg/Kg), which has not exceeded the limit set by Directorate General of Food and Drug Administration Decree Number 03725/B/SK/VII/1989 of 2.0 mg/Kg.

1 INTRODUCTION

The pace of development in all sectors under current conditions has led to an increase in the rate of urbanization. The logical consequence of all this is the increase in urban activity in various sectors, both housing, industry, trade and other sectors. One of the impacts of such development is the depletion of agricultural land used as a source of food and as the population grows increased food demand continues to increase.

Food is an essential basic human needs and the fulfillment of the food need should be fairly equitable and based on the independence and not contrary to the beliefs of society as mandated by Law Number 7 of 1996 on food.

In 2014, Mangrove Forest Management Hall I Bali has provided counseling on alternative food ingredients, one of them is lindur (*Bruguiera gymnorrhiza*). Fruit lindur (*Bruguiera gymnorrhiza*) is one of the mangrove fruit plants commonly known as mangrove leaves large. Fruit lindur (*Bruguiera gymnorrhiza*) has been used as a substitute for rice. According to Fortuna (2005), lindur (*Bruguiera gymnorrhiza*) is suitable to be explored as a new high-quality carbohydrate, which is 85.1 g/100 g of ingredients.

The current problem is the habitat of the lindur plant (*Bruguiera gymnorrhiza*) itself. Where, lindur plant (*Bruguiera gymnorrhiza*) is one type of mangrove that lives in the coastal waters with low salinity and dry and the land has a good aeration.

Ecotourism Mangrove Surabaya becomes one of the places to grow lindur plants (*Bruguiera gymnorrhiza*). Waters in Ecotourism mangroves are waters that are influenced by the tides and the sea is influenced by the sedimentation process. Ecotourism of mangroves is located on the coast as well as a gathering place of polluting substances or waste carried by the river. The waste comes from industrial
activities in urban areas, households as well as from visitors of ecotourism of mangrove forest.

Of the many wastes that exist in coastal areas, heavy metal waste is the most dangerous because it causes toxic effects for humans (Boran and Altinok, 2010). Heru Setiawan (2013) said that coastal waters are waters that have the high potential for metal accumulation. Heavy metals are said to be hazardous pollutants because they are toxic and non-degradable and easily absorbed. Pollution of heavy metals entering the aquatic environment of the river will dissolve in water and will accumulate in the sediment and may increase over time, depending on the environmental conditions of these waters (Wulan et al., 2013).

Heavy metal Pb is one of the most dangerous heavy metals, and in both low and high levels, heavy metal Pb is toxic and has a negative impact, one of which is for lindur (Bruguiera gymnorrhiza). If the plant contains heavy metal Pb then it will lead to poisoning when consumed by humans (Yunita, 2011).

According to Luh, et al (2015) said that in lindur (Bruguiera gymnorrhiza) there is a heavy metal content of Pb that grows in the area of the Dead River is $116.04 \pm 2.09$ mg/kg, and in Pemogan area of $12.85 \pm 0.61$ mg/kg. In the study stated that the heavy metal content of Pb has exceeded the threshold according to Directorate General of Food and Drug Administration Decree Number 03725/B/SK/VII/ 1989 on the maximum limit of heavy metal contamination in food (Pb of 2.0 mg/kg). This research have problem formulation are the waters and sediments found in Wonorejo Mangrove Ecotourism Surabaya containing Pb heavy metals and is lindur (Bruguiera gymnorrhiza) used as an alternative foodstuff containing heavy metal Pb.

2 LITERATURE REVIEW

Supriatna and Safari (2009) suggested several regional names from Bruguiera gymnorrhiza, namely taheup, tenggel (Aceh); wax, red tinjiang (Jakarta); putut, tumu (Riau); lindur, red long (Bali); bangko (NTT); salasala, totongkek (NTB); tancang (West Java); tancang, tumu (Central Java); tancang, putut (East Java); lindur (Madura); tokke-tokke, sala-sala, tancang, tokke (South Sulawesi); and big mouth (East Kalimantan).

Based on its taxonomy, the classification of lindur (Bruguiera gymnorrhiza) is as follows (Kartesz, 2011):

- **Kingdom**: Plantae (plants)
- **Sub kingdom**: Tracheobionta (vicious)
- **Super division**: Spermatophyta (yielding seed)
- **Division**: Magnoliophyta (flowering)
- **Class**: Magnoliopsida (double-dikotil)
- **Subclass**: Rosidae
- **Order**: Myrtales
- **Family**: Rhizophoraceae
- **Genus**: Bruguiera
- **Species**: Bruguiera gymnorrhiza (L.) Lamk.

According to BPHM I Denpasar (2014) lindur (Bruguiera gymnorrhiza) has a tall tree reaching 20 m, small knee-rooted knee, simple opposite leaf arrangement, ellipse, crossed, tapered end, leaf length 8-15 cm, . Leaves are slick and thick, with no rough and slim ends. The bark is dark gray, rough, has a bark mouth.

Flowering year-round. Flower width, single in leaf armpit, large, red, 3-5 cm long, petals 10-14 strands, white to brown crown, the tip of each shaped crown consists of 3 stems of stamens.

Fruit shaped cylinder, slippery, diameter 1.7-2.0 cm long, 20-30 cm long, dark green to purple with brown spots. The petals coalesce when the fruit falls, it can float, spread by water.

Fruit is usually divided into real fruit and fake fruit. Fruit lindur (Bruguiera gymnorrhiza) allegedly classified in a false fruit (fructus spurius). Fake fruit is divided into three namely single pseudo fruit, double false fruit and pseudo compound fruits. Fruit lindur (Bruguiera gymnorrhiza) can be classified single pseudo fruit because it occurs from one flower with one will fruit. In this fruit other than going to fruit there are other parts of the flowers that come form the fruit (Tjitrosoepomo, 1996).

Lindur (Bruguiera gymnorrhiza) is the dominant species in high mangrove forests and is characteristic of late coastal forest developments, as well as early stages of transformation into mainland vegetation types. Grows in acreage with low and dry salinity and good aerated soil. This species is tolerant of both sheltered and sunny areas. They also grow on the edge of the mainland from mangroves, along the ponds as well as retro and brackish. Found on the beach only if there is erosion on the land in front of him. The substrate consists of mud, sand, and sometimes black peat soil. This species is sometimes also found in rivers that are less affected by sea water. This may be caused by the carrying of lindur (Bruguiera gymnorrhiza) by the water or tidal wave. Regeneration is often only in limited quantities. The flower is relatively large, has reddish petals, hangs, and invites birds to pollinate (Indah, 2011).
Lindur plant (*Bruguiera gymnorrhiza*) able to help stabilize the soil, protect the beach, and as the habitat of various fauna. The wood can be used as firewood and to make charcoal. Pepagan (bark) is used as a tannery material and a good fish nets preservative because it contains an average tannin of 28.5-32.2% (Glen, 2005). In addition, Solomon residents utilize pepagan to heal burns. In small islands, Indonesia is used to treat diarrhea and fever, while in Cambodia it is used as anti-malaria (Duke and James, 2006). Residents in remote islands use their young leaves as vegetables or vegetables. The inside of the hypocotyl lindur (*Bruguiera gymnorrhiza*) can be eaten (candied candy), mixed with sugar. The eastern Indonesian population utilizes lindur (*Bruguiera gymnorrhiza*) as a source of food during the famine season (Glen, 2005).

### 3 METHODS

The tools used in this study include drill, AAS, evaporator, modified DO bottle, glass cup, capillary tube, plastic, kater, preparation, pH water meter, pH meter and erlemeyer.

Materials used include 10 mL of water, 10 grams of sediment and 10 grams of lindur (*Bruguiera gymnorrhiza*), 10 mL HNO3 and 25 mL HCl, 100 mL of aquades, oxygen, asitelin, NO3, NaCl.

To perform the research procedure through several methods ie first method (1) Testing of Physics Parameters on Water and Sediment (Temperature, pH, Salinity) (2) Water and sediment sampling (3) Samples of lindur (*Bruguiera gymnorrhiza*) used are lindur (*Bruguiera gymnorrhiza*) that is old and characterized by the characteristics of brown fruit and red petals. Samples of lindur (*Bruguiera gymnorrhiza*) were taken at each station with three repetitions.

Second method (1) Test of Heavy Metal Pb on Water. Water as much as 10 mL, and inserted into a cup glass, then evaporated to dryness using evaporator tool. The formed residue is transferred to the turbidity of the porcelain so that it becomes ash. Then added 25 mL of HCl, 100 mL HNO3 and 100 mL of aquades. Then, in a stirred and filtrate clear filtrate and inserted into the AAS tool with absorbance 217 nm. (3) Testing Heavy Metal Pb on Lindur Fruit (*Bruguiera gymnorrhiza*). The lindur sample (*Bruguiera gymnorrhiza*) was washed with water. Then the sample is taken layer of epidermis, mesoderm layer and layer of endoderm with each 10 gram. The layer then burned to dry. The resulting residue was transferred to the porcelain plate to be burnt to ash, then added 25 mL of HCl, 100 mL HNO3 and 100 mL of aquades. Then, stirred to dissolve the ash, filter filtrate filtered and inserted into the AAS tool with absorbance 217 nm.

### 4 RESULTS AND DISCUSSION

Parameters of aquatic physics observed in this study include temperature, pH, and salinity. The results of the measurement of the parameters of aquatic physics are presented in Figure 1.

![Figure 1: Aquatic Physics Parameters.](image-url)

Shown in figure 1 is the average temperature condition is 29.59 °C, 29.22 °C, 29.12 °C. According to Effendi (2003), the more intensity of sunlight on the body of water will make the river water temperature higher. Similarly, the more and denser vegetation around the water circle it will make the air temperature around to be lower. Temperature is still within the limits of water quality standard according to Decision of Environment Minister Number 51 of 2004, where the standard water temperature of 28-32 °C. The mean values of pH were 6.70, 6.60, and 6.62. Endang, S and Nirwani, S (2015) says that rain will affect the pH of the aquatic environment to acid. Harry and Yuliandi (2010) say that the pH of the water is getting to the estuary more acidic due to the addition of organic materials which then liberate the CO2 if it decomposes.

If rainwater falls on the ground then in the soil cavity meets with carbon dioxide, then the water is more acidic again and then will form acid salts. This will last long if a lot of CO2, if no more CO2 then the...
acid salt will decompose into CaCO3. The reactions as follows.

\[
\text{CaCO}_3 + \text{H}_2\text{CO}_3 \rightarrow \text{Ca} (\text{HCO}_3)^2\text{ decompose}
\]

\[
\text{Ca} (\text{HCO}_3)^2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2
\]

According to Hendri (2015) said that the higher the temperature of the waters the pH will decrease. The pH conditions of the three stations are below the water quality standard limit according to Decision of Environment Minister Number 51 of 2004, where the pH quality standard is in the range of 7-8.5.

The average salinity value is 1.69 %, 1.73 %, and 1.79 %. The average salinity value is below the threshold set by Decision of Environment Minister of 2004 that is salinity value 33 till 34 %. According to Nybakken (1992), the conditions of estuary waters are affected by land and sea. Where the high salinity value occurs when the influence of the oceans is more dominant than the influence of the land, that is when the pairs occur. While the low salinity value is caused by the influence of land, that is when fresh water enters the waters through the river flow.

Physical parameters in the sediments observed in this study include temperature, pH, and salinity. The physical condition of the waters can affect the physical and chemical content in the soil as it accumulates and is absorbed by the sediment (Ika et al, 2014). Results the measurement of physical parameters in the sediments is presented in Figure 2.

Shown in figure 2 is the average temperature is 29.78 °C, 29.78 °C, and 28.66 °C. Average pH of 6.67, 6.58, and 6.66. Rainfall affects the pH value in sediments (Endang, S & Nirwani, S, 2015). In addition to rainwater, soil pH is also affected by the residual metabolism of microorganisms present in the sediments. According to Lay (1994) states that during the growth of microorganisms, there is often a change in the pH of sediment, whereas when the metabolism of proteins and amino acids are released, the ammonium ions cause the pH to be alkaline. The average salinity value is 1.67 %, salinity 1.69 %, and 1.73 %. The salinity of the soil, lower than the salinity of the waters, can be caused by mangrove which is a freshwater plant that can change the salt content found in the soil to be bargaining for metabolic processes that require fresh water (Ika et al, 2014).

The result of measurement of heavy metal content of Pb on water in Wonorejo Mangrove Ecotourism is presented in figure 3.

![Figure 3: The Content of Heavy Metal Pb On Water.](image)

Shown in figure 3 is the mean values of heavy metal concentrations of Pb of water were 0.92 mg/L, 0.86 mg/L, and 1.08 mg/L. Although the levels of heavy metals in water are relatively small, they are very readily absorbed and biologically accumulated by plants or aquatic animals and will be involved in food tissue systems. The low level of heavy metal in water due to the dilution process in water, then heavy metal is absorbed by suspended particles going to the bottom of the waters, this causes the heavy metal content in low water (Deny, 2016). The concentration of heavy metal Pb in Wonorejo Mangrove Ecotourism has exceeded the threshold of water quality standard according to Decision of Environment Minister Number 51 of 2004 is 0.005 mg/L. The result of measurement of heavy metal content of Pb on sediment can be seen in Figure 4.

![Figure 4: The Content of Heavy Metals Pb In Sediments.](image)

Shown in figure 4 is the heavy metal content of Pb in sediments was 2.69 mg/kg, 2.92 mg/kg, and 2.98 mg/kg. According to Rochyatun et al (2006), heavy metal levels in sediments are higher than in water, this
indicates the presence of heavy metal accumulation in sediments, possibly because heavy metals in water undergo dilution processes with the effect of current patterns. The heavy metal content of Pb sediment is still below the threshold due to Government Regulation of Republic of Indonesia Number 85 of 1999 which is equal to 5.0 mg/kg.

The result of measurement of heavy metal content of Pb on lindur fruit (*Bruguiera gymnorrhiza*) can be seen in figure 5.

![Figure 5: Heavy Metal Content of Pb on Lindur Fruit (*Bruguiera gymnorrhiza*)](image)

Fruit is the last place of translocation and the most important part that must be protected from something that can damage or inhibit its growth, because in the fruit there will be new plants. Utilization of mangrove fruit as a food ingredient has become a habit of society since long. Fruit lindur (*Bruguiera gymnorrhiza*) is used as an alternative food because the mangrove fruit has a higher carbohydrate content (Fortuna, 2005).

Shown in figure 5 above, the average weight of Pb weight on lindur (*Bruguiera gymnorrhiza*) in station I was 0.13 mg/kg, station II was 0.15 mg/kg and station III 0.16 mg/kg. The highest content of heavy metal Pb is found in station III. This is because the sediment and water at station III also have a high content of heavy metal Pb, so lindur (*Bruguiera gymnorrhiza*) can absorb more Pb metal. According to Grant, C.A et al, (1998), the heavy metal content of Pb most accumulates in lindur mangrove plants (*Bruguiera gymnorrhiza*) due to the ability to trans transmit heavy metals greater than the fruit other types of mangroves.

Pb levels in water and soil affect the level of Pb in lindur (*Bruguiera gymnorrhiza*). The Pb in the water which then enters the soil will be absorbed by the roots and will be distributed to other parts of the plant (Rizka et al, 2015). At the root, zak enters the cell by diffusion either by active diffusion or passive diffusion (Taiz, 2010). The binding of heavy metals to plants is through the formation of complex compounds and in the presence of root-eating root crop root extracts a number of organic acids such as malic acid, citric acid, fumarate, phenolics that cause pH around rooting decreases (Tan, 2000). As a result, many heavy metal compounds and ions become dissolved so that it is absorbed by the plant. Heavy metals penetrating endodermic roots cause other metals to be transported by the transpiration stream to the top of the plant through the transport network (xylem) to other parts of the plant (Rizka et al, 2015). According to Priyanto and Prayitno (2007) on cells and tissues of heavy metal plants Pb will undergo a detoxification mechanism, for example by storing (hoarding) metals in certain organs such as fruits, leaves, and plant roots.

The mean value of heavy metal Pb in lindur (*Bruguiera gymnorrhiza*) at station I, epidermal layer 0.13 mg/kg, mesodermic layer 0.15 mg/kg, and endodermic layer 0.16 mg/kg. The mean value of heavy metal content of Pb in the epidermal layer is 0.10 mg/kg, mesodermic layer of 0.04 mg/kg, and endodermic layer of 0.26 mg/kg, at station II epidermal layer of 0.13 mg/kg, a mesodermic layer of 0.05 mg/kg and an endodermic layer of 0.27 mg/kg, at epidermal layer III station of 0.14 mg/kg, mesodermic layer of 0.06 mg/kg and an endodermic layer of 0.29 mg/kg.

The three stations show that the heaviest layer of heavy metal content of Pb is found in the endodermic layer, compared to the epidermal layer and mesodermic layer. It is suspected in the epidermal layer and the mesodermic layer has a thin layer and has a large intercellular space so that the heavy metal content of Pb dissolved in water easily penetrates the layers. According to Siluh (2012), the epidermal layer on the lindur (*Bruguiera gymnorrhiza*) is arranged tightly together with each other forming a square without intercellular space. The epidermis layer has a thin cell wall in the absence of thickening by kutin on the lindur (*Bruguiera gymnorrhiza*). In the mesodermis layer there is the cortex, where the cortex of the lindur (*Bruguiera gymnorrhiza*) is composed of thin-walled cell layers, having intercellular space for gas exchange. It’s role as a reserve food storage. In lindur (*Bruguiera gymnorrhiza*) there is also a vacuole, Tjitrosoepomo (1996) says the vacuole is a space in fluid-filled cells, a membrane of membranes (tonoplasts). This liquid is water and various substances dissolved in it. Vakuola has several functions such as storage of food substances such as starch and glucose. Therefore, the endodermis layer
has the highest heavy metal content, due to the epidermal layer and the mesodermic layer having thin walls so that the heavy metal content of Pb can enter easily to the endodermis layer with the help of water as a means of transportation. In the study, Siluh (2012) said in lindur (*Bruguiera gymnorrhiza*) has a water content of 62.92%. This results in the accumulation or accumulation of Pb heavy metals in the endodermic layer.

The high content of heavy metal Pb is also supported by surrounding medium, such as temperature, pH, and salinity. According to Deri et al. (2013), the decrease of salinity and acid pH will increase the solubility potential of heavy metals. The higher the temperature of water, the solubility of heavy metals such as Pb will also be higher, and vice versa (Rosmaria Oliva, 2009).

However, the lindur (*Bruguiera gymnorrhiza*) has a heavy metal content of Pb that has not exceeded the threshold set by Directorate General of Food and Drug Administration Decree Number 03725/B/SK/VII/1989 of 2.0 mg/kg, so that the lindur (*Bruguiera gymnorrhiza*) is still quite safe for consumption. However, if the lindur (*Bruguiera gymnorrhiza*) is consumed continuously it will give a negative impact on health because it contains Pb heavy metals.

**CONCLUSION**

Based on the results and discussion, then from this research can be drawn some conclusions that the water and sediments found in Ecotourism Mangrove Wonorejo Surabaya has experienced heavy metal pollution Pb. While lindur (*Bruguiera gymnorrhiza*) contained in Ecotourism Mangrove Wonorejo Surabaya heavy metal content Pb does not exceed the threshold that have been set by Directorate General of Food and Drug Administration Decree Number 03725/B/SK/VII/1989 at 2.0 mg/kg.

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