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The Environmentally Sound Aquaculture Strategies Based on Bioaccumulation of Heavy Metal of Lead (Pb) on Seaweed of *Gracilaria verrucosa* on Aquaculture Areas of MuararejaVillage, Tegal City

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Abstract. Community activities such as industry, trade, animal husbandry and agriculture and ssettlements resulting in heavy metals of lead (Pb) can be accumulated in water, sediment and seaweed *Gracillaria verrucosa*. It can contaminate ponds and affect aquaculture activities in Tegal. Seaweed *Gracilaria verrucosa* is afisheries commodity that has economical value and cultivated in the area of aquaculture MuararejaTegal. It can serve as fitoremedian that will help reduce the impact of heavy metal pollution due to its ability to accumulate pollutants. The objective of this study was to analyze bioaccumulation of heavy metals of lead (Pb) and its relationship with water quality management in order to develop seaweed cultivation of *Gracillaria verrucosa* in ponds in the area of aquaculture MuararejaTegal. The method used in this study is a survey, analysis of heavy metals of lead (Pb) in pond water, sediment and seaweed using *Atomic Absorption Spectrophotometer* (AAS) and the data were analyzed by descriptive quantitative. Bioconcentration of lead (Pb) during the dry season in pond water, sediment and seaweed *Gracillaria verrucosa* was measured from 0.003 to 0.025 ppm,5.543 to 23.699 ppm and 0.209 to 0.326 ppm respectively. While in the rainy season bioconcentration of lead (Pb) are from 0.003 to 0.015 ppm, sediment from 6.377 to 9.858 ppm and 0.209 to 0.326 ppm respectively. Bioconcentration of Pb in dry season was higher than in the rainy season and the biggest bioconcentration was found in the sediment pond waters. Pb bioaccumulation low and still below the quality standards of the Ministry of Environment decision 51 of 2004 so that the product is safe for consumption.

Keywords: Pond management strategies, environmental, heavy metals Pb, seaweed *Gracilaria verrucosa*

1. Introduction

Population activities such as agriculture, animal husbandry, fisheries, industryand settlements cause various pollutions including heavy metals such as lead (Pb). This pollutant will contaminate the aquatic environment including the pond, mainly in the Muarareja village. The village has the widest pondin Tegal.

Heavy metals Pb can be derived from nature or impact of population activities. Generally, heavy metals enter into the aquatic environment through atmospheric deposition, erosion of geological matrix or due to anthropogenic activities caused by industrial effluents, domestic sewage and mining wastes [1].

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Qari and Shidiqy [2] said that heavy metals are toxic and not degradable, but can be absorbed through the water and the food chain and can accumulate inseaweed.

Pollutants that enter the aquatic environment will undergo a process of accumulation, either physical, chemical or biological. The accumulation of physical and chemical pollutants will precipitate in the bottom waters as sediment of pond, while biological pollutant will be absorbed by organisms.
Wardhana [3] states that the process of moving a toxic substance from the water to the organism is called bioconcentration; while the movement of toxic compounds through the food chain to an organism is called biomagnification. Toxic materials such as Pb if absorbed will accumulate in water, sediment and seaweed. It will be having an effect on the sustainability of aquaculture. The content of Pb high in the water can also be a negative impact on the organisms in it as said by Palar [4] that the Pb concentration reached 188 mg/l, can kill fish.

Pb containe in the water will cause the process of bioaccumulation in the body of biota in the waters, such as fish. The content of Pb in the body would interfere with the activity of enzymes, such as aminolevulinic acid dehidrase (-ALAD), Hem synthetase, and another enzyme involved in the systemhemotopoietik.

Gracilaria verrucosa, one of a class of marine algae Rhodophyta (red algae) [5-6] does not have different structure between the roots, stems and leaves, and overall plant organ is known as thallus. Thallus has the ability to produce gelatin widely used in the food industry, one of which is used as a thickener or food stabilizer. Common characteristics of *Gracilaria verrucosa* is body-type branched form clumps with irregular branching, dichotomous, thallus form lamellar or cylindrical, cartillagenous, generally tapered tip thallus, smooth surface thallus or nodule thallus, with diameters ranging from 0.5 - 4.0 mm, a length of 30 cm or more and a greenish brown color [7].

Lead is more commonly known as the black lead, in scientific language is called plumbum, and the metal is symbolized by Pb. These metals included in the categoryofmetal IV- A on the periodic table of chemical elements, having atomic number (NA) 82 and has atomic weight (BA) 207.2 [4]. Pb in water comes from dust containing Pb that is caused by the burning of gasoline containing Pb tetra ethyl, erosion and industrial waste.

The objective of this study was to analyze the bioaccumulation of heavy metals Pb and its relationship with water quality and environmentally sound aquaculture management strategiesfor the development of environmentally sound aquaculture in seaweed ponds of *Gracilaria verrucosa* in the area Muarareja Tegal.

2. Material and Methods

This research was conducted in the seaweed (*Gracilaria verrucosa*) pond in Muarareja, Tegal. The method used in this study is a survey. Data were analyzed by quantitative descriptive variables in the study. GIS methods were used to determine the location of the research.

Data collected included primary data and secondary data. Primary data were obtained from the survey results/observations in the field and interviews. Secondary data were obtained through references from several institutions associated with the research. The variables in this study, namely heavy metals (Pb), temperature, salinity, pH, DO, ammonia, nitrate, phosphate, organic matter, and the substrate. Water quality analysis was conducted in the Integrated Laboratory of the Faculty of Fisheries and Marine Sciences, University of PancasaktiTegal. Analysis of heavy metals of lead (Pb) from the pond water, sediment and seaweed was carried out in the Laboratory of the University of Jenderal Soedirman Purwokerto using *Atomic Absorption Spectrophotometer* (AAS). Sampling technique is purposive/judgmental sampling or based on certain considerations.

Determining the location of sampling based on certain considerations, such as ease of reaching the point of sampling, as well as time and cost efficiency are based on the interpretation of the initial study site. Sampling is limited to the sample unit in accordance with certain criteria (characteristics of the soil) that is determined by objective research. Sampling for water and soil was conducted in eight seaweed ponds and two estuary of Kemiri River in aquaculture Muarareja.

3. Results and Discussion

Topography Tegal has a sloping beach, weak currents and waves is ramps. These topography are suitable for aquaculture of seaweed *Gracilaria verrucosa*, fish and shrimp vanname, both monoculture and polyculture systems.

3.1 Water Quality Parameter

Tegal's coast is low-lying, sandy clay substrate, tropical climate, and the average temperature is 27,9ºC. Results of water quality measurements during the study are presented in Figure 1. In general, water quality parameters are still within the limits that can be tolerated by seaweed of *Gracilaria verrucosa*. The quality of aquaculture is aquaculture of seaweed *Gracilaria verrucosa*, fish and shrimp vanname, both monoculture and polyculture systems. Tegal's coast is low-lying, sandy clay substrate, tropical climate, and the average temperature is 27,9ºC. The quality of aquaculture is strongly influenced by environmental conditions. If there is contamination it will greatly affect the cultivation.

According to Widigdo [8], other factors affecting the productivity of the pond is soil fertility. With good water quality conditions and fertile land, natural food is expected to grow well. Besides the fertility of the soil, the content of substances that are toxic are the the factors that affect the quality of the production.

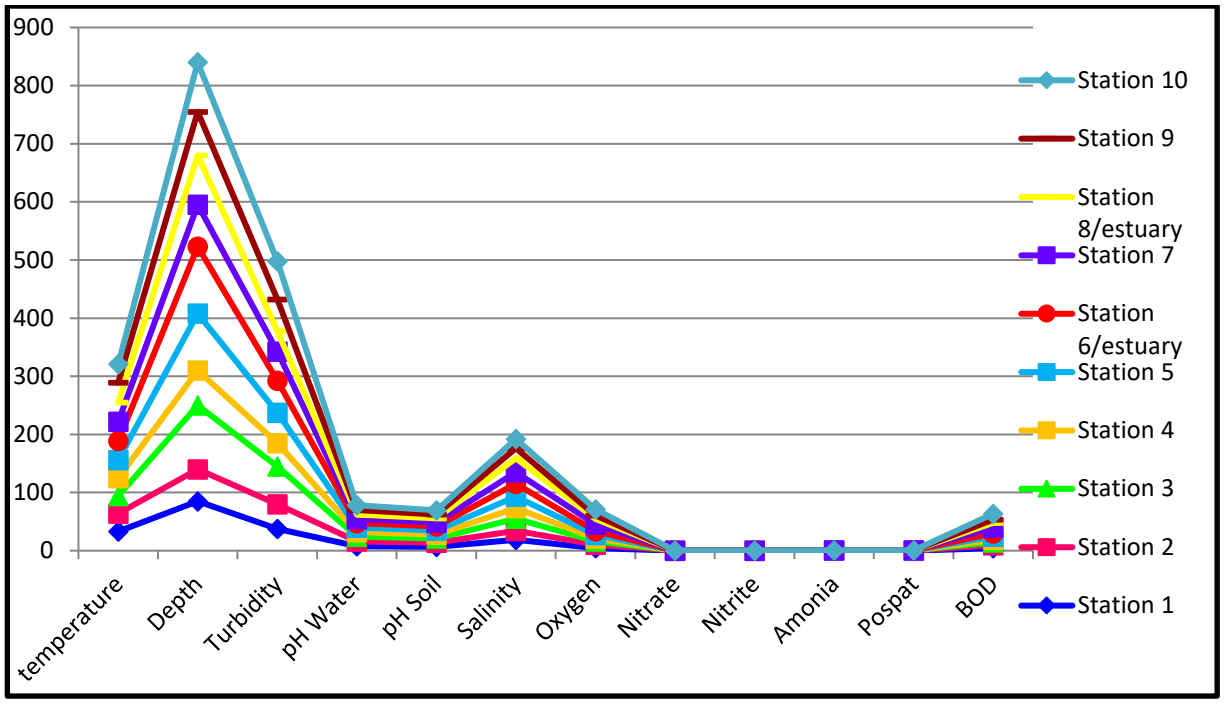


Figure 1. Measurement Water Quality of Pond in Rainy Season

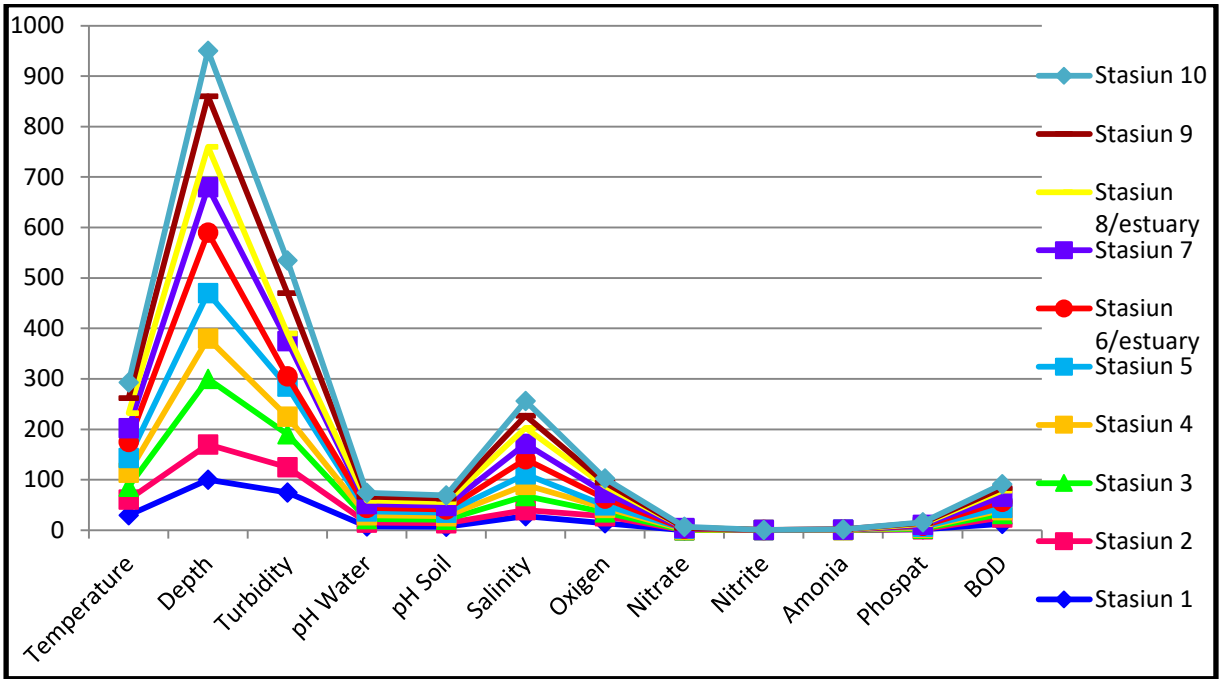


Figure 2. Measurement Water Quality of Pond in Dry Season

The parameters of water quality during the research were still within acceptable limits for the life and growth of seaweed *Gracilaria verrucosa.*

3.2 Heavy Metals Lead (Pb) in The Water

Darmono [9] also explains that the industrial waste containing Pb, such as the chemical industry, printing, metal, and paint will be wasted in the waters; it will increase the metal content of lead in the waters. The content of heavy metals of lead (Pb) or bioconcentration in pond water during the study is illustrated in Figure 3.

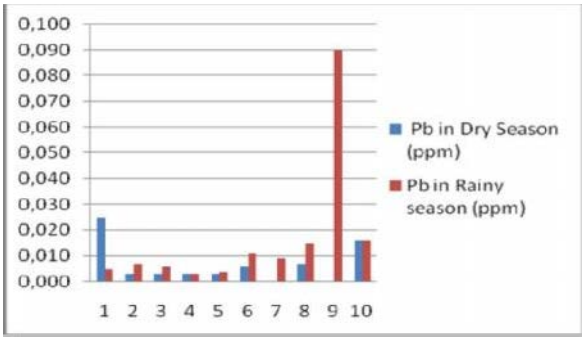


Figure 3. Content of Heavy Metals Lead (Pb) in the Water of Pond Research

The content of Pb in the water of pond was 0.003 to 0.016 ppm during the rainy season and from 0.003 to 0.025 ppm during the dry season. The highest content of Pb was in the pond near the grave because the pond is close to a water channel that carries various waste products from industrial waste, settelments waste, agriculture and fisheries. The content of Pb in pond water during the dry season is higher than in the rainy season. This is caused at the rainy season and there is a process of dilution, so the concentration of Pb is relatively lower. According to Palar [4], concentration of Pb in waters is influenced by the seasons. In the rainy season, the metal concentrations in water would be smaller than

the dry season because during the rainy season the dilution process occurs, while in the dry season, the metal will be concentrated [9].

Argawala [10] states that the tolerance limits of aquatic organisms are at pH 5- 9; if there are pollutants that disrupt the aquatic buffer system, it will cause serious disruptions to aquatic organisms. The content of Pb in the water pond of research is still low, and the parameters of water quality during the study were still within acceptable limits for the life and growth of seaweed *Gracilaria verrucosa*. Normal Pb levels on the earth's surface <12.5 ppm [11-12]. Therefore Pb level in these waters including the normal category.

3.3 Heavy Metals Lead (Pb) in Seaweed Gracilaria verrucosa

Heavy Metals Lead (Pb) in Seaweed *Gracilaria verrucosa* in dry season and rainy season can be in Figure 4. Seaweed, *Gracilaria verrucosa*, is known of having an ability to absorb Pb in the water [13].

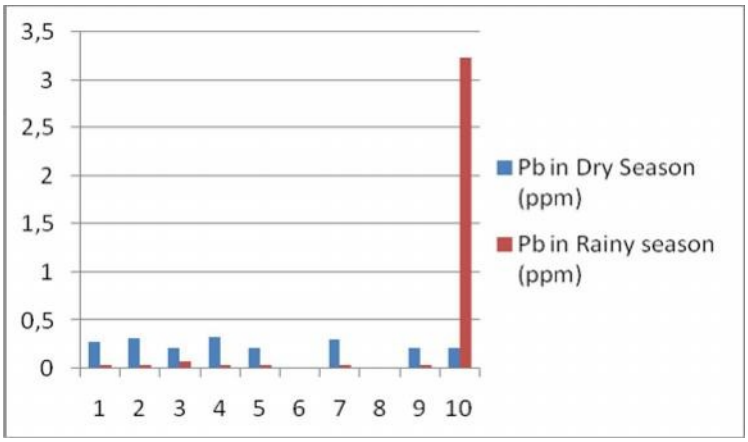


Figure 4. Content of Heavy Metals Lead (Pb) on Seaweed *Gracilaria verrucosa*

The content of Pb in seaweed *Gracilaria verrucosa* in ponds is 6.469 to 9.858 ppm in the rainy season and from 5.543 to 23.699 ppm in the dry season. The highest content of Pb was in settlement ponds because the waste from the settlement contains Pb. For station 6 (estuary of Kemiri II river) and station 8 (mouth of Kemiri River I) there is no Pb containing in seaweed. Pb bioconcentration in seaweed *Gracilaria verrucosa* in the dry season was higher than in the rainy season. Sorensen [14] stated that the higher the content of heavy metals in the water, the higher concentration of heavy metals accumulated in the body of the organism.

Darmono[15] also stated that the accumulation of heavy metals in the body of the organism depends on the concentration of heavy metals in the water. Bioaccumulation is the net result of which the absorption of contaminants by organisms beyond the ability of the organism to eject (depuration) from the body. Bioaccumulation can occur through respiration, digestion or direct contact with contaminated water or sediment [16].

3.4 *Heavy Metals Lead (Pb) in Sediment*

Haevy metals Pb can accumulate in sedimen because of the organic material produce by humus. Heavy Metals Lead (Pb) in Sediment can see in Figure 5.

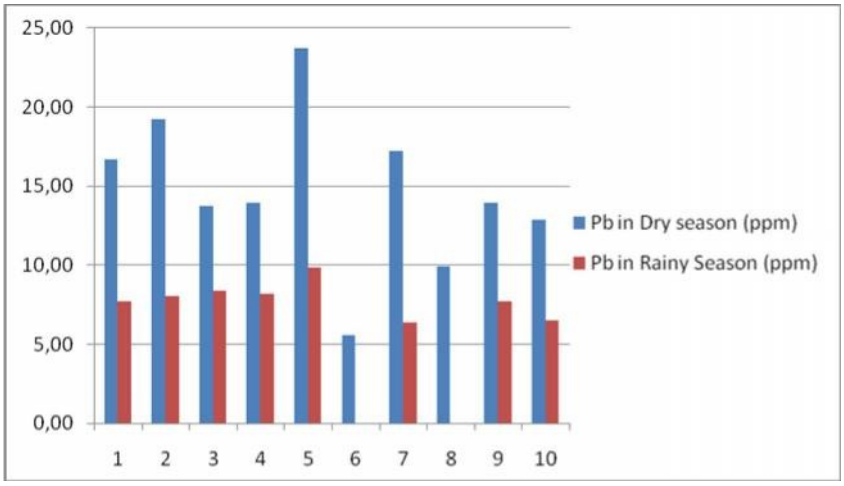


Figure 5. Bioconcentration of Heavy Metals Lead (Pb) in the Sediments of Ponds Research

The content of Pb in the pond sediment is 6.469 to 9.858 ppm in the rainy season and from 5.543 to 23.699 ppm in the dry season. The content of Pb was highest in the pond near the settlement. The content of Pb in the sediment in the dry season was higher than in the rainy season because of the increase in lead concentration. Heavy metals have easy binding properties of organic materials; settle to the bottom of waters, and blends with sediment, so the concentration of heavy metals in sediment was higher than in water [17]. In general the metal content of Pb decreases with increasingly thick layers of sediment [18]. Pb in water comes from dust containing Pb as a result of the combustion of gasoline containing tetra ethyl lead, erosion and industrial waste.

Table 1. The Range of Pb's Content during Research

Sample	Pb's content (ppm)	The Ministry of Environment decision 51/2004(ppm)
Pond's Water	0–0,025	0,008
Pond's Sediment	5,543–23,6990	>30
Seaweed *Gracilaria verrucosa*	0,209–0,326	2

Darmono [9] also explains that the industrial waste containing Pb, such as the chemical industry, printing industry, metal industry, and the paint will increase the concentration of Pb in the water. *Gracilaria verrucosa* is one class of marine algae Rhodophyta (red algae) which can function as a biofilter because it has the ability to absorb heavy metals. One way to reduce the pollution of Pb is using seaweed *Gracilaria verrucosa* as fitoremedian and can be used as bioindicators of water pollution, it is reinforced by research from [19-23].

The highest bioconcentration of Pb was in sediments in the pond water of seaweed (*Gracilaria verrucosa*) in Muarareja Tegal. Sediment of ponds is an accumulation medium of various organic materials as shown by results of research conducted by Ikbal *et al.*[24] and Ishak *et al.*[25]. Thus it can be said to have occurred bioaccumulation of Pb, where Pb in the pond water is lower than in seaweed (*Gracilaria verrucosa*) and the highest is in the sediment and it is a appropriate Suryono [26]. The Canadian Council of Ministers for the Environment (CCME) [27] and Ministry of Environment [28] set the Threshold Limit Threshold Pb value in sediments for biota protection respectively of 35 ppm and 36.8 ppm.

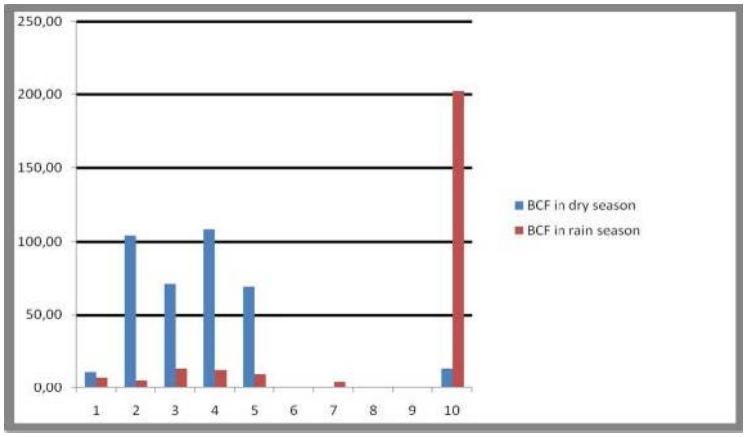


Figure 6. Bioaccumulation of Heavy Metals Lead (Pb) in Dry Season and Rainy Season

This is consistent with research by Ata *et a*, [29] and Tamilselvan *et al* [22] that *Gracilaria verrucosa* is able to absorb heavy metals Pb effectively; and Chakraborty *et al* [30] stated *Gracilaria verrucosa* can absorb heavy metals. Among the heavy metals, Pb, Cd, and Hg are highly toxic heavy metals than other heavy metals. The heavy metal pollutants are very dangerous if they contaminate the waters, because they are toxic, carcinogenic, bioaccumulative and biomagnification.

According to Matos *et al* [31], the integrated culture system of fish and seaweed can improve the feasibility of land for cultivation, because it can reduce the risk of damage to water quality and nutrients are released into the environment, and one of the good biological filter used in aquaculture is seaweed *Gracilaria sp.* Sohrab *et al* [32] research about The Environmental Monitoring of Heavy Metals in Seaweed and Associated Sediment.

The integration is an aspect which is essential in a system of resources management of coastal and marine. This not only ensures the synchronization between the internal policies and action programs, the projects and programs, but also ensures linkages between planning and implementation. Based on the type, integration can be divided into three types of integration, namely (1) the integration of systems, (2) integration of function and (3) policy integration [33]. According to Dahuri *et al* [34], integration of planning and integrated coastal zone management includes four (4) aspects, namely: (1) integration of the region/ecological; (2) integration of the sector; (3) the integration of science disciplines; and (4) the integration ofstakeholders.

Pollution in water can occur either because of industrial waste and domestic waste are discharged into waters without being processed first, or processed but the pollutant levels are still above the Standard Quality specified. The Pb's content from research results when compared to the quality standard of the Ministry of Environment Decree No. 51 [35] was still below the quality standard so that the seaweed is still safe for consumption.

4. Conclusion

Based on the results of the study, itcan be summarized as follows:

1. Pb bioconcentration during the dry season in pond water, sediment and seaweed (*Gracilaria verrucosa*) are respectively 0.025, 0.003 ppm, 5.543 to 23.699 ppm and0.209 to 0.326 ppm. While in the rainy season bioconcentration of lead (Pb) is respectively 0.003-0.015 ppm, sediment from 6.377 to 9.858 ppm and 0.209 to 0.326. Pb bioconcentration is greater during the dry season than during the rainy season.
2. Bioaccumulation of heavy metals is still relatively low, and the content of Pb is still below the quality standard of the Minister of the Environment Decree No.51 of 2004 so that the product is safe for consumption.
3. Water quality parameters during the study arestill within the limits that can be tolerated by seaweed (*Gracilaria verrucosa*).

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