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The Analysis of Mangrove Ecosystem Based on the Nutrient Content of the Substrate and the Density of the Mangrove in Karangsong Village, Indramayu District, Indramayu Regency

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Abstract

Indramayu is one of the districts with the longest coastline of 147 km stretching along the northern coast of Cirebon and Subang in which most of the mangrove ecosystems grow. The rapid population growth caused the need for natural resources and land, both for settlements and livelihoods, to increase as well, including in coastal areas. The quality decline of the mangrove environment will affect the distribution of nutrient content in the sediments that will also be impactful to the fertility of the mangrove. The purpose of this study is to examine the mangrove ecosystems based on nutrient content of the substrate in Karangsong Village, Indramayu District, Indramayu Regency. The study was conducted in June 2018. The study employed a survey method with Point Quarter Method sampling techniques. The data obtained were analyzed descriptively and comparatively, then statistically analyzed using Cluster and Multidimensional Scaling (MDS) analysis. The results showed that the nutrient content either nitrate, phosphate, organic substances and the substrate texture, was suitable and supportive for the life of the mangrove. The density of the mangroves in the ***seedling*** stage is categorized good (ind 5.000 ind / ha), the density of the ***saplings*** are categorized very good (≥ 5.000 ind / ha), while the ***tree*** stage is in a very dense category (≥1.500 ind / ha). There are 2 groups of mangrove planting sites based on the condition of their location, namely group 1, consists of stations 1, 2, and 4 (2008, 2009, and 2011) and group 2 consists of stations 3, 5, and 6 (2010, 2012 and 2013).

Keywords: Mangrove, Nutrient, Substrate, Density, *Point Quarter Method*, Karangsong.

INTRODUCTION

Indramayu is one of the districts with the longest coastline of 147 km stretching along the northern coast of Cirebon and Subang where most of the mangrove ecosystems grow. The potential of mangrove forests in Indramayu is 3,925 ha spreading in several areas, one of which is in Karangsong village. The village stretches in coastal areas with a 2 kilometer coastline length. It is topographically a lowland area with a 3 meters height above the sea level. Since 1982, mangrove forests in Karangsong Village have been gradually disappeared due to the land clearing for ponds and residents' settlements. Damage to the habitat or mangrove ecosystem will have an impact on the supporting resources around it.

Mangrove ecosystems are part of the coastal ecosystem. Coastal areas are transitional ecosystem between the land and the ocean. The land boundary, which covers the inundated and the non-inundated areas by the sea water, is still affected by processes from the sea, such as tides and sea breeze. The boundary towards the ocean includes waters which are still influenced by natural processes in the land, such as sedimentation, river water flow into the sea and human activities [1]. The mangrove vegetation generally grows to form zoning ranging from the shore to several meters before the land. The zoning of mangrove forests is an eco-physiological response of plants to environmental gradations [2]. The quality of mangrove environment will affect the distribution of nutrient content in the sediments which are also impactful to the fertility of mangroves.

Based on the above description, this study aims at studying mangrove ecosystems based on their nutrient content in the substrate in Karangsong Village, Indramayu District, Indramayu Regency.

RESEARCH LOCATION

The research was carried out at the sites of the mangrove planting in Karangsong Village, Indramayu District in Indramayu Regency in June 2018. The location coordinates of the study site can be seen in Table 1.

Table 1. Coordinate Point of Research Location

Station	Planting Year	Coordinate	
		E	**S**
1	2008	108º 22’ 07.14’’BT	6º 18’ 12.87”LS
2	2009	108º 22’ 05.41’’BT	6º 18’ 12.53”LS
3	2010	108º 22’ 11.17’’BT	6º 18’ 08.60”LS
4	2011	108º 22’ 06.49’’BT	6º 18’ 08.51”LS
5	2012	108º 22’ 10.57’’BT	6º 18’ 08.24”LS
6	2013	108º 22’ 05.27’’BT	6º 18’ 11.47”LS

MATERIALS AND METHODS

The study employed the survey method, which is to observe and systematically record the mangrove forests using *Point Quarter Method* sampling techniques [3].

The criteria for the mangrove growth stages can be seen in Table 2.

Mangrove density calculation:

$$\text{Density (ind/ha): } \frac{10.000\ m2}{average\ of\ tree\ distance}\ x\ Number\ of\ Species\ Points$$

The standard criteria for mangrove damage can be seen in Table 3.

To measure the condition of the mangrove ecosystem based on the nutrient content of the substrate, a statistical analysis was employed by using *Cluster* and *Multidimensional Scaling (MDS)* analysis.

Table 2. The Criteria of Mangrove Growing Phase [4]

Mangrove Growth Stages	Criteria
Seedling	Trees from 2 to high leaves < 1.5 cm
Sappling	Tree saplings with a height of ≥ 1.5 m and diameters up to <10 cm ≥ 1.5 m dan diameter to < 10 cm
Tree	Trees with chest-height diameter ≥ 10 cm

Table 3. Standard Criteria for Mangrove Damage [5]

	Criteria	Closing (%)	Tree Density Level (ind/ha)
Good	Highly	≥ 75	≥ 1500
	Moderate	≥ 50-≥ 75	≥ 1000 - < 1500
Broken	Seldom	< 50	< 1000

RESULTS AND DISCUSSION

Referring to Table 4, the measurement of nitrate in mangrove sediments in Karangsong Village has a range of 23,72-34,49 mg/kg. This is a very high fertility

category. Nitrate content with the value < 0,227 mg/kg is classified as infertile, 0,227 – 1,129 mg/kg classified as moderate fertility, 1,130 - 11,250 mg/kg classified as high fertility, and > 11,250 mg/kg classified as very high fertility [6]. The horizontal distribution of nitrate level is getting higher towards the coast and the highest levels are usually found in estuarine waters, due to the presence of nitrate sources from the land in the form of nitrate-containing wastes [7]. Nitrate serves to repair the vegetative part of the plant and to form proteins. The potential source of nitrate derives from organic materials such as urea and from the activity of microorganisms that convert undigested food waste and metabolic remnants of dead fish and plants in the pond. Potential nitrates will affect the process of absorption of other micro and macro nutrients [8]. As a whole, the level of nitrate in Karangsong Village is suitable for the habitat of mangrove vegetation.

Table 4. The nutrient content of substrate in Karangsong Village, Indramayu District, Indramayu Regency

Station	**The Content of Nutriene Substrate**		
	Nitrate (mg/kg)	**Phosphate (mg/kg)**	**Organic Materials (%)**
1	27.72	14.71	9.19
2	23.72	14.70	12.73
3	24.23	13.49	10.64
4	32.25	18.25	11.68
5	34.49	14.60	9.70
6	33.87	15.07	9.23

The levels of phosphate in mangrove sediments in Karangsong Village range from 13,49 - 18,25 mg/kg. The value is in the normal category. The source of phosphate comes from the abundance of natural fertilizers (guano), rock erosion, and the inclusion of detergent waste, agriculture and fisheries into the mangrove area [9]. Overall, the phosphate levels in Karangsong Village, Indramayu District, Indramayu Regency are still within normal limits. Phosphate functions for cell formation, formation of albumin, fruit, seeds, and flowers, to ripen plants and strengthen stems. Phosphate will be easily absorbed by plants in neutral pH conditions. The ideal phosphate range for habitat for mangrove vegetation is ≤ 16-30 mg /kg [6].

The results of measurements of organic material in mangrove sediments in Karangsong Village range from 9,19 to 12,73%. This value is in the normal category. According to the Minister of Environment Decree No. 51 of 2004, the quality standard for organic materials is 0.001 - 30%. Total organic material is often interpreted as carbon organic material, since it is the main constituent of living things [10]. Carbon element is the basic framework (backbone) of all the compounds exist in the body of living things. The content of organic materials in the sediments of mangrove land comes from local primary productivity which is mostly contributed by mangrove (autochthonous) trees and inputs carried by surface water stream. Therefore, the extent of mangrove vegetation and forests along the watersheds, as well as anthropogenic activities, can affect the total organic matter content in the mangrove environment.

Referring to Table 5, the value of the substrate texture obtained in Karangsong Village for clay fractions ranged from 7,01 to 11,54%, the dust fraction ranged from 13,38 to 22,72%, while for the sand fraction it only ranged from 65,75 to 79,61%. On Table 5, it can be seen that the texture class in Karangsong Village includes the sand class. The sand texture has the highest value, while the clay texture has the lowest average value. In general, the soil type in the alluvial mangrove forest is blue to grayish brown. This land is in the form of rigid mud with high clay proportions, varying from blue clay which is compact with a little organic matter, to black brown mud soil which is easily released because it contains a lot of sand and organic matter [9].

Table 5. The Substrate Texture in Karangsong Village, Indramayu District Indramayu Regency

Station	Fraction		
	Clay (%)	**Dust (%)**	**Sand (%)**
2008	8.14	20.62	71.58
2009	7.01	13.38	79.61
2010	9.74	19.67	70.59
2011	9.93	20.67	69.40
2012	9.22	21.24	69.55
2013	11.54	22.72	65.75

Table 6. The density rate of mangroves in Karangsong Village, Indramayu District, Indramayu Regency

Station	Species	Seedling	Sapling	Tree
1	*Avicennia alba*	-	44,950	53,074
	Avicennia marina	-	47,965	18,166
	Rhizophora apiculata	-	31,279	-
	Rhizophora mucronata	-	28,499	-
	Total	**-**	**152,693**	**71,240**
2	*Avicennia alba*	-	-	-
	Avicennia marina	2,500	25,040	59,464
	Rhizophora apiculata	-	11,568	-
	Rhizophora mucronata	-	94,860	24,669
	Total	**2,500**	**131,468**	**84,133**
3	*Avicennia alba*	-	-	-
	Avicennia marina	2,750	128,563	49,500
	Rhizophora apiculata	-	-	-
	Rhizophora mucronata	6,750	127,806	5,882
	Total	**9,500**	**256,369**	**55,382**
4	*Avicennia alba*	-	-	-
	Avicennia marina	250	17,241	54,273
	Rhizophora apiculata	-	-	-
	Rhizophora mucronata	250	153,125	37,250
	Total	**500**	**170,366**	**91,523**
5	*Avicennia alba*	-	-	-
	Avicennia marina	750	184,519	10,000
	Rhizophora apiculata	-	-	-
	Rhizophora mucronata	2,750	146,920	6,250
	Total	**3,500**	**331,439**	**16,250**
6	*Avicennia alba*	-	-	-
	Avicennia marina	1,500	161,534	52,083
	Rhizophora apiculata	-	-	-
	Rhizophora mucronata	3,250	127,312	26,666
	Total	**4,750**	**288,846**	**78,749**

Seen in Table 6, the density rate of mangroves in Karangsong Village, at the seedling stage ranged from 0 to 500 ind/ha with an average of 4.150 ± 3.371 ind/ha. The value is in a good category. This criterion is based on the Evaluation Guidelines of the

Directorate General of Land Reforestation in 1997, the mangrove density values for seedling stages can be categorized as very good (≥ 5.000 ind / ha), both (≥ 2.500-5.000 ind / ha) and very poor (≤ 2.500 ind / ha). This is because the difference in potential regeneration of the mangrove vegetation seedling which is caused by differences in regeneration ability in each type of mangrove and its ability to adapt to the environment. It can be seen from the number of individuals each type found at each different observation point. The seedling station I of 2008 was not found, the 2009 2-year planting station was dominated by the *Avicnnia marina* species (2.500 ind / ha). The 3-year planting station in 2010 was dominated by *Avicennia marina* (2.750 ind / ha) and *Rhizophora mucronata* (6.750 ind / ha). The 2011 4-year planting station was dominated by *Rhizophora mucronata* and *Avicennia marina* respectively (250 ind / ha), at the 5-year planting station 2012 was dominated by *Rhizophora mucronata* (2.750 ind / ha) and *Avicennia marina* (750 ind / ha) as well as station 6 2013 planting year was dominated by *Rhizophora mucronata* (3.250 ind / ha) and *Avicennia marina* (1.500 ind / ha).

The density rate of mangroves in Karangsong Village, at the staging stage 131.468 – 331.439 ind/ha with an average of 221.864 ± 81.599 ind / ha. This value is in a very good criteria. This criterion is based on the Evaluation Guidelines of the Directorate General of Land Reforestation in 1997, the mangrove density values at the stake can be categorized as very good (≥ 5.000 ind / ha), both (≥ 2.500-5.000 ind / ha) and very poor (≤ 2.500 ind / ha). The high density value of the *pancang* stage indicates that the regeneration of mangrove vegetation for the sapling stage is very good. The high potential of saplings in the mangrove area is because the mangrove ecosystem is a result of rehabilitation so that the process of planting is very concerned about the type of mangrove that can grow with existing conditions. Seen from the number of individuals, each type which is found at the observation point, is only of a few types. At station 1, the 2008 planting year, it was dominated by *Avicennia marina* (47.496 ind / ha), *Avicennia alba* (44.960 ind / ha), *Rhizophora apiculata* (31.279 ind / ha) and *Rhizophora mucronata* (28.499 ind / ha). Station 2, planting year 2009, was dominated by *Rhizophora mucronata* (94.860 ind / ha), *Avicennia marina* (25.040 ind / ha) and *Rhizophora apiculata* (11.568 ind / ha). Station 3, planting year 2010, was dominated by *Avicennia marina* (128.563 ind / ha) and *Rhizophora mucronata* (127.806 ind / ha). Station 4, planting year 2011, was dominated by *Rhizophora mucronata* (153.125 ind / ha) and *Avicennia marina* (17.241 ind / ha), at station 5, planting year 2012, dominated by *Avicennia marina* (184.519 ind / ha) and *Rhizophora mucronata* (146.920 ind / ha). Station 6, 2013 planting year, dominated by *Avicennia marina* (161.534 ind / ha) and *Rhizophora mucronata* (127.312 ind / ha).

The density rate of mangroves in Karangsong Village, at the tree stage ranges from 16.520 to 91.523 ind/ha with an average of 66.213 ± 27.414 ind / ha. The value is in a very dense category. This criterion is based on the Decree of the State Minister of Environment No. 201 of 2004 concerning Standard Criteria and Guidelines for Determining Mangrove Damage, density of trees with very dense values (≥ 1.500 ind / ha), medium (≥ 1.000 - <1.500) and rare (<1.000 ind / ha). This is because all

observation points are in the rehabilitation area so it is very important for the growth of mangrove vegetation. The density of mangroves in the site of the study also shows that the dominating species are able to adapt to the surrounding environment and have a tendency to form a diversity of stand structures which play an important role as traps of sediment deposits, form communities to stabilize coastlines, protect coastal erosion, support sea and land to absorb wave energy, inhibiting intrusion of sea water to land. Producing habitats to support species diversity and anatomical tissue of mangrove plants is very effective in storing carbon and absorbing pollutant materials to reduce pollution from the environment (Dahuri, 2001). The dominating types at Station 1 in 2008 were *Avicennia alba* (53.074 ind / ha) and *Avicennia marina* (18.166 ind / ha). At station 2 of 2009 it was dominated by Avicennia marina (59.464 ind / ha) and *Rhizophora mucronata* (24.669 ind / ha). Station 3 in 2010 was dominated by *Avicennia marina* (49.500 ind / ha) and *Rhizophora mucronata* (5.882 ind / ha). At station 4 in 2011 it was dominated by *Avicennia marina* (54.273 ind / ha) and *Rhizophora mucronata* (37.520 ind / ha). Station 5 in 2012 is dominated by *Avicennia marina* (10.000 ind / ha) and *Rhizophora mucronata* (6.250 ind / ha) and station 6 in 2013 dominated by *Avicennia marina* (52,083 ind / ha) and *Rhizophora mucronata* (26.666 ind / ha).

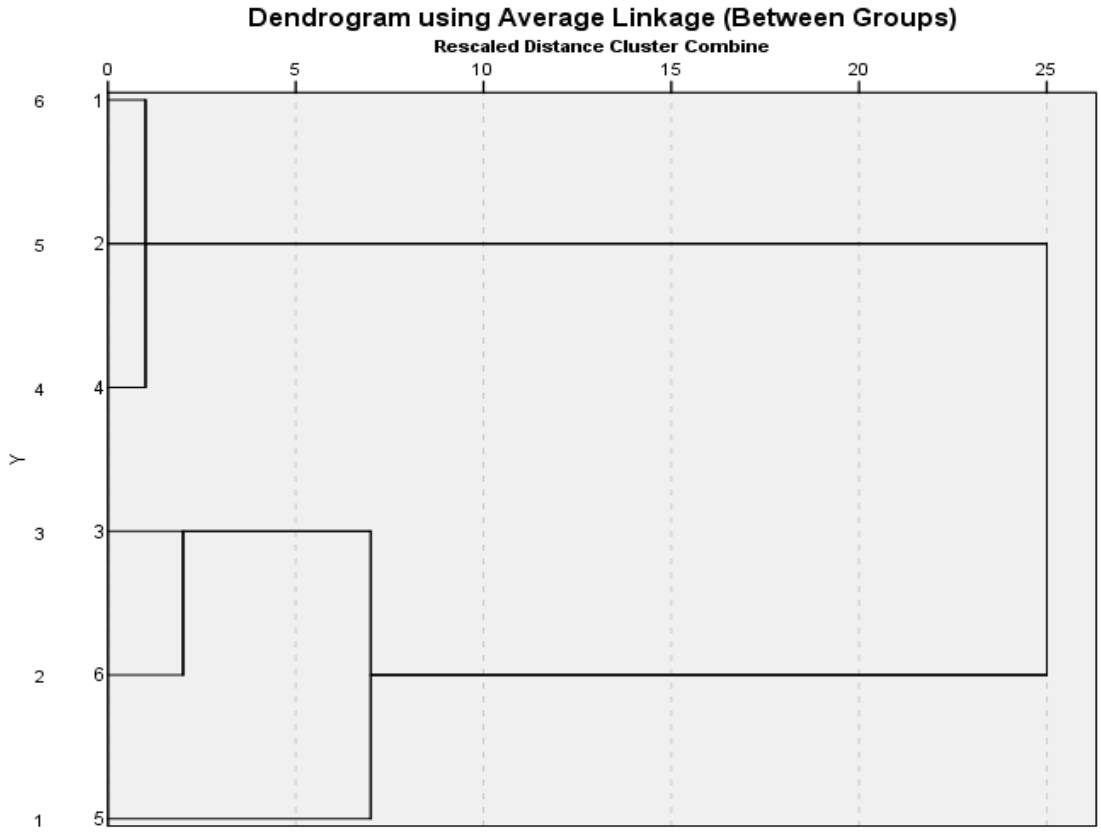

Figure 1. Graph of characteristic similarity between mangrove planting locations

The above analysis (Figure 1) demonstrates that there are 2 groups of mangroves having similar characteristics based on the condition of the location, namely:

a. The first Cluster members consisted of 3 stations namely station 1 (planting year 2008) and station 2 (planting year 2009) and station 4 (planting year 2011).
b. The second Cluster member consists of 3 stations namely station 3 (planting year 2010), station 6 (planting year 2013) and station 5 (planting year 2012).

Can be seen in Figure 2, each station has a dominating characteristic according to the proximity of the distance between the variables. Based on their similarity in characteristics, stations 1, 2 and 4, share a common characteristic proximity in having high content of substrate nutrients such as nitrate, phosphate and organic matter and clay fraction, dust and sand. As from their types of mangrove, they share typical types of mangroves, namely types of *Avicennia marina*, *Rhizophora apiculata* and *Rhizophora mucronata*. Stations 3, 5 and 6, have proximity to the characteristics of low substrate nutrient content but have similar characteristics that are high based on the level of density of mangroves. Viewed from the type of mangrove that grows has similarities, namely the types of *Avicennia marina* and *Rhizophora mucronata*.

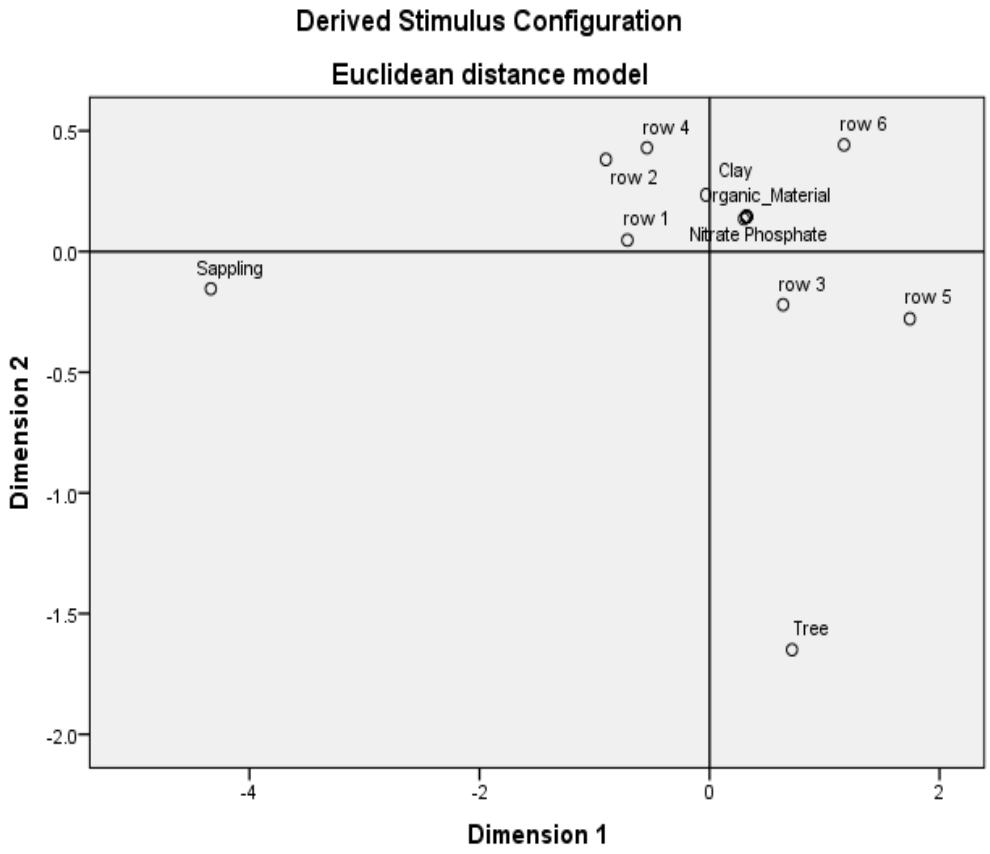

Figure 2. The graph of *Derived Stimulus Configuration Euclidean Distance Model*

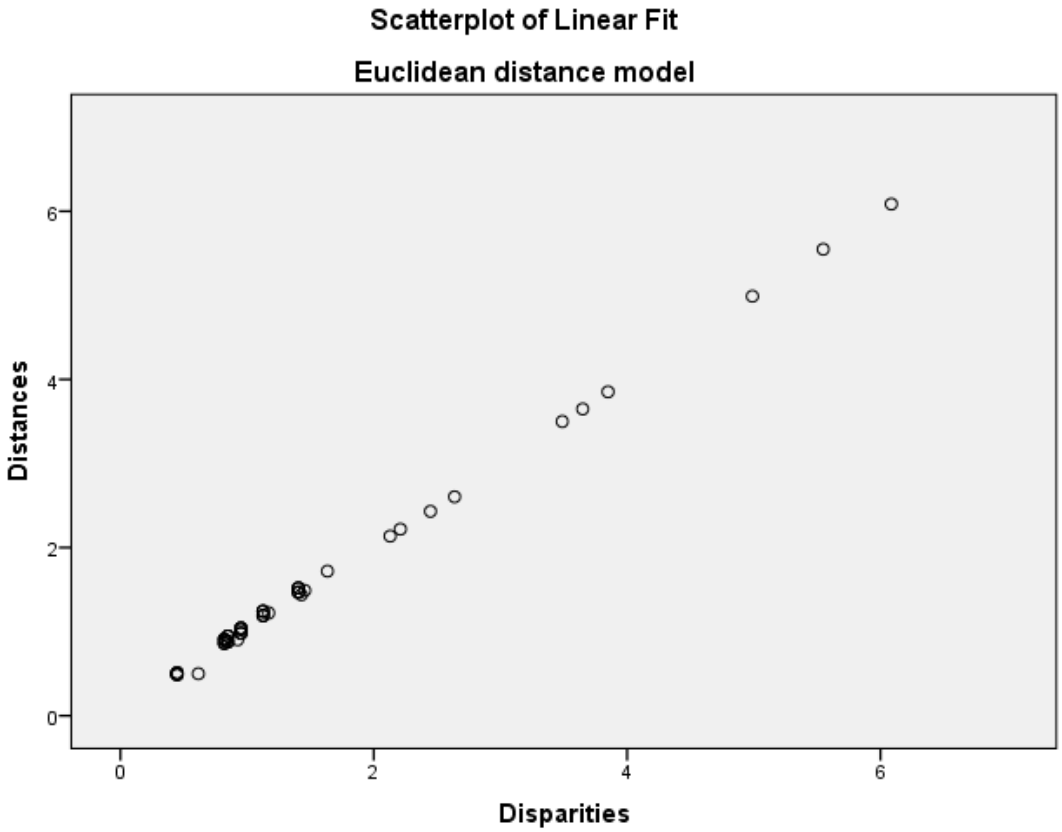

Figure 3. The graph of *Scatterplot of Linear Fit Euclidean Distance Model*

Based on the graph above (Figure 3), it can be seen from a number of variables may form a straight line (linear). This demonstrates the consistency of the mangrove ecosystem in assessing the similarity based on nutrients on the substrate and the level of density of mangroves. In the graph, several groups of coordinates are exposed. This is due to the different characteristics of the mangrove planting stations.

CONCLUSION

The content of nutrient, either nitrate, phosphate, organic materials, and the substrate texture is appropriate and supports the life of the mangrove. The density of mangroves in the seedling stage is in the good category (≥ 5.000 ind / ha), the saplings are in a very good category (≥ 5.000 ind / ha) and the tree stage is categorized as very solid (≥1.500 ind / ha). Based on the condition of the location, namely group 1 consisted of stations 1, 2 and 4 (planting years 2008, 2009 and 2011) and group 2 consisted of stations 3.5 and 6 (planting years 2010, 2012 and 2013).

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