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COVER PHOTO (FRONT) SUNSET AT LOSARI BEACH, MAKASSAR (courtesy of A.Y. Baeda): LAKE OF HASANUDDIN UNIVERSITY, PURA ULUN AT BEDUGUL LAKE (BACK)

NATURAL SUCCESSION VEGETATION AREA CHARACTERISTICS IN THE TAILINGS DEPOSITION AREA OF PT FREEPORT INDONESIA AT PAPUA INDONESIA

Y. Windusari [1] , Z. Dahlan [1], Indra Yustian[1] and P.Puradyatmika[2]

ABSTRACT: Tailings are natural rock residues after the process of mineral extraction of ore. PT Freeport Indonesia uses the mineral extraction process using physical methods of *physical grinding* and *flotation*. To study how the revegetation process takes place in the tailings deposition area, a research is carried out and includes the study on the character of the area based on the parameters of physics, chemistry, and biology. Inactive tailings deposition area called Double Levees is a extensive area of research with ± 15,000 ha. Secondary and primary data collected between 2009 and 2010. Samples are taken using the line transect method and data were analyzed by multivariate statistics. The results indicate that the character of chemistry and physics at the Double Levees deposition area tend to be similar. This significantly affects the structure and composition of vegetation growing in the area of succession. The structure and composition of vegetation succession on the path of observation tend to have similar type. But the diversity of species were higher in areas with fine particles.

Keywords : Natural succession vegetation, tailings, ModADA

INTRODUCTION

In general, the vegetation in each region have the capability of adaptation. Some areas with similar physical conditions will be covered in vegetation with a high resistance to extreme conditions (Pourmirza, 1994 in Reyhan & Amiraslani, 2006). Soil productivity is the ability of a soil to produce a specific vegetation and is a manifestation of non-soil and soil factors which influence each other, although the fertile soil is not necessarily productive (Yuwono & Rosmarkam 2008). Healthy soil contributed greatly to the quality of soil which can be described as soil properties.

The physical condition of the soil affects the vegetation community associations in the type and climate (light, radiation, wind, temperature and humidity) is very influential in the regeneration conditions (Sykora et al., 2004). Different soil types, topographical variations and changes substantsially lead to differences of vegetation structure and eomposition as they relate to the spread of seeds (Whitmore, 1998; Frouz et al., 2008).

Soil stability and availability of nutrients play as the basic life of the organism. Organisms in an ecosystem haves a specific nature and varyies from place to place. Soil physical properties such as the lime content, soil saturation, pH and salinity of the soil affects the vegetation cover of an ecosystem (Zarinkafsh, 1987 in Reyhan & Amiralani, 2006). Uhl et al., (1988) and Maiti and Singh (2001) explains that the area disturbed, less fertile, or extreme conditions could potentially have re-colonization of vegetation, but more stable soil conditions favor one or more species of vegetation lost to re-occupy the area or colonization vegetation. Colonization of species increases the number of species.

Succession of natural vegetation in the Double Levee area is interesting to study because of growing on nutrient poor soils and difficult to predict areas overgrown with vegetation. Double Levee is an inactive tailings deposition area in the MODADA (Modified Ajkwa Deposition Area) and is relatively stable. MODADA, a lowland region of Ajkwa in the south of Papua island at Eastern of Indonesia is used to manage and contain tailings of PT Freeport Indonesia. Characteristics of the natural vegetation succession related physical and chemical soil conditions were studied in this research.

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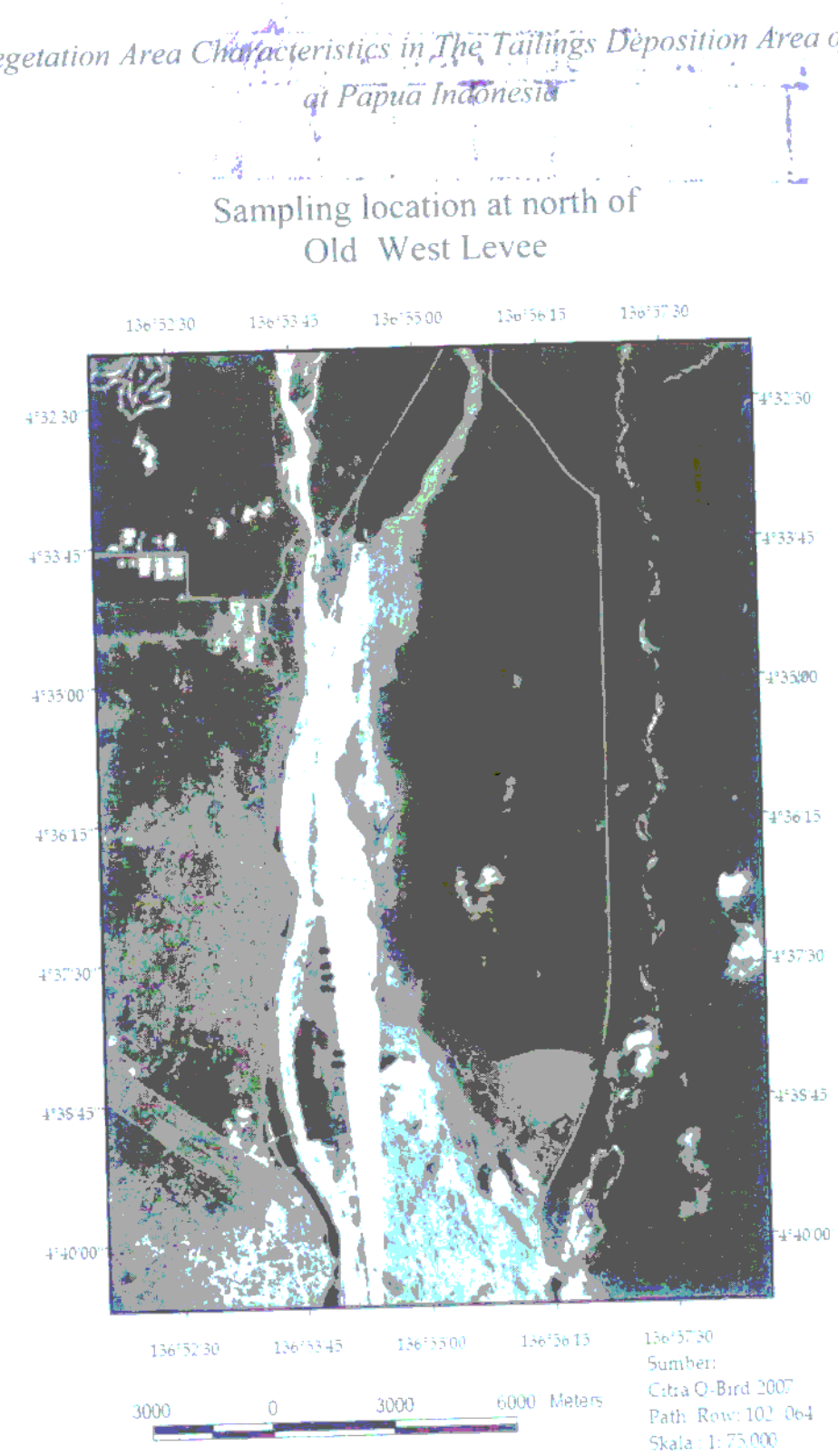

Fig. 1a Sampling location at Double Levee area :

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Field site and sampling

Double Levee is located on the ordinate 136°45'00 "- 137°07'00" BT and 04°20'00 "- 04°55'00" LS. Rainfall in the region is 375 mm / month with an average of 22 days of rainy days / months, the temperature of 26°C and 75-82% humidity. Tailings particles gradually deposit from large particles that settle in the upper ModADA, medium and fine particles in the middle, and fine to very fine particles of sediment in the downstream to the estuary. Method of revegetation within the study site is divided into 2 (two) types i.e. natural succession and reclamation. Vegetation age ranges from 4 to 25 years. Sampling distribution of each blocks reflects the condition of each region and type of growth.

The study was conducted during April-July 2009.

RESULT AND DISCUSSION

The results show geomorphological area of particle deposition and distribution led to some areas in the Double Levee be permanent or periodic flooding, Laboratory (TEL) and in the laboratory of the Department of Land and Natural Resource Sciences,
Soil analysis performed in the Timika Environment Faculty of Agriculture IPB, while the identification of species of vegetation by using Manual of Tropical Forests of Papua. Determination of sampling block image data based on a scale of 1:600 Q-Bird and the sampling point based on GPS data. Examples of observations were taken from 27 transects in the Old West Levee and 40 transects in the New West Levee. The grouping of vegetation types using the cluster method.

and partly of dry land. These conditions form some type of vegetation in the Double Levee (Figure 2 and Table 1).

Tailings particle size associated with the soil pore space. The southern part is an area of medium to fine particles. Small-sized particles of the tailings pile, causing soil to be solid and the narrowing of the pore space. Influence of river runoff (in part through the new Ajkwa river) water-saturated region and lead to increased humidity. As a result, the soil pH in the New West Levee area tends to be lower than in the Old West Levee area. PH conditions affect nutrient Mo, and availability of all the macro nutrients (except P), whereas the value Fe, Mn, Zn, Cu, and Co become so low that inhibit plant growth. Organic matter content and N-total is very low causing a slump in the CEC. Total P content as very high, while the P-are very low. Total K-content in the topsoil, including medium-and K-are relatively low. Levels of Ca ion exchanged as very high. Elevated levels of Ca in the soil are due to the addition of lime during ore processing and tailings before entering MODADA.

The existence of primary forest as a source of seeds and wild fauna, as well as the influence of local climate supports the process of seed dispersal in the deposition of tailings. Kilimasskosu (2003) stated that the process of seed dispersal in the tailings deposition area of PT Freeport Indonesia supported a variety of natural factors such as carried by wildlife, wind, gravity, and water. Mixing of natural sedimentation on the flow of tailings material allows the availability of soil supporting the growth of a species of vegetation in the area of tailings deposition. The succession led to a growing number of nutrients in the soil. Manlay *et al.* (2000) suggests an increase in soil chemical constituents such as calcium, magnesium and total carbon, and CEC in the topsoil increased over the succession.

Chemical factors such as soil pH, N-total, the levels of major elements such as P, K, Na, Ca, Mg, CEC and organic C-actively influence the growth of vegetation. Increasing the number of species, density and diversity of vegetation species showed increased growth of vegetation. Changes in micro-climatic conditions and vegetation structure increases the complexity of developing and improving humus in the soil surface layer (Parrotta, 2000). Increased complexity of vegetation structure influenced the entry of seeds carried by various external factors, while the presence of *Phragmites karka* improves soil microclimate.

Bioedaphic factors influences changes in the presence of a species in a forest. Hassan *et al.* (2007) stated that edaphic factors such soil texture, moisture, bulk density, particle size, organic matter and nutrient content and climatic factors (weather conditions, pests, and animal distribution, competition and growth) greatly influenced the development of crops and increasing the microenvironment and regulate the structure and functioning of ecosystems. Bhatt (1990) explains the existence of an invading species of vegetation native grasses during the succession process in the mining region plays an important role in increasing the diversity of forest communities. Meanwhile, according to Manlay *et al.* (2000) introduced species presence in an ecosystem, desert ecosystems primarily affect the development of vegetation. The presence of these species forms the interaction between these factors in the ecosystem and above.

Organic matter content in the region tend to be low New West Levee is believed related to the dominance of *Casuarina equisetifolia*. In fact, this area is used as a reclamation area of *Casuarina equisetifolia*. The process of decomposition of litter species occur relatively slowly. Reclamation process inviting a wild fauna to come and occupy the reclaimed area (Nepstad, 1991). The presence of wild fauna helps spread the seeds, so the natural succession in the area of reclamation is rapid, although the development of natural vegetation tend to be hampered by vegetation reclamation. Parrota (2000) states that the habitat preferences and behavior facilitator is influential in creating the structure and composition of vegetation, including the selection of trees that will accelerate the increase in species diversity.

Variation in vegetation communities associated with improving the quality of the soil which affects the increase in species diversity. By Sykora *et al.* (2004), accumulation of organic matter and increase in number of species takes place during the succession. Rouhi-Moghaddam *et al.* (2007) explains that the invasion of natural vegetation on the reclaimed area influence the type of species that occupy the region. On degraded lands, the reclamation plant regeneration of natural species because it helps accelerate the improvement of micro-climate, and as a competitor of the natural species. Based on this, the reclamation of forests play important role to create long-term harmony of ecosystems because it can facilitate the succession of natural vegetation and increase species diversity.

The uniqueness of revegetation on the observation area is a natural form of forest succession in a short time and relatively quickly, also increasing the diversity of vegetation in the reclamation region. This is shown in the improvement in soil quality. Development of soil at Double Levee is indicated by variations in the thickness of the surface horizon (Taberima, 2009). According to Schafer *et al.* (1980 in Taberima, 2009), pedogenesis takes place when the process stops and the deposition of tailings tailing interaction with climatic factors, chemical and biological happen, and takes time and varies in some places due to the different composition (Néel *et al.*, 2002).

Figure 2 and Table 1 shows the composition of species in forest succession of natural vegetation in the Double Levee closely related to the physical condition of the environment and the chemical content of the soil. Chemical content of soil in the downstream region tends to increase with improved physical condition of the environment. The downstream of the Double Levee area dominated by sandy clay or dusty clay which is included in both categories and tended to have good drainage and fertile characteristics by high species diversity of vegetation. *Phragmites karka* found in some areas were flooded. Distribution patterns of organic materials have approximately the same value range, except for the B3BB.

The similarity of the texture of dusty clay soil on the block B6BB observations, B7BB, B8BB, B9BB cause the chemical content of the soil are similar. Dusty clay texture has the ability to bind to soil nutrients is more powerful than the sand. Concentrations of base cation tend to be larger than the other blocks. As a result of cation exchange (CEC) also increased relative to an average of 3.79 me/100g, and the increased value of organic materials to an average of 0.59% in each region.

Area of natural succession in the south (B1BL and B2BL) has a CEC value is greater than in the central region, but the organic matter content, K, and Na are lower. The low K sandy loam soil texture due to lost or dissolved water. K will be replaced Na concentration. Similarity of physical and chemical characteristics of soil is also influenced by topography and geography of the adjacent area. B1BL block *Casuarina equisetifolia* is a reclamation area and is developing very well with high species diversity. All levels of plant growth found in this region, but the dominance of seedlings is still there. The presence of Pandanus and Moraceae families into the process of succession indicators and increasing organic matter content is an indication of the activity of microorganisms.

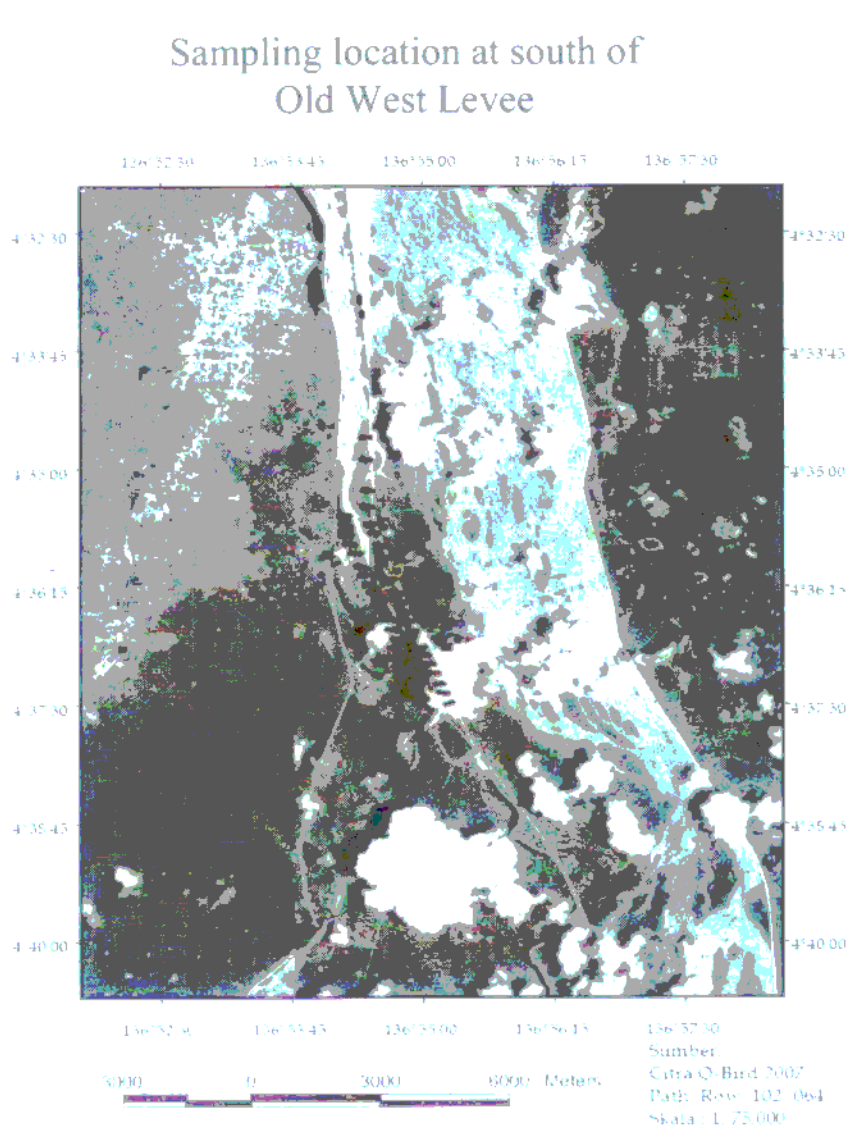

Fig. 1b Sampling location at Double Levee area

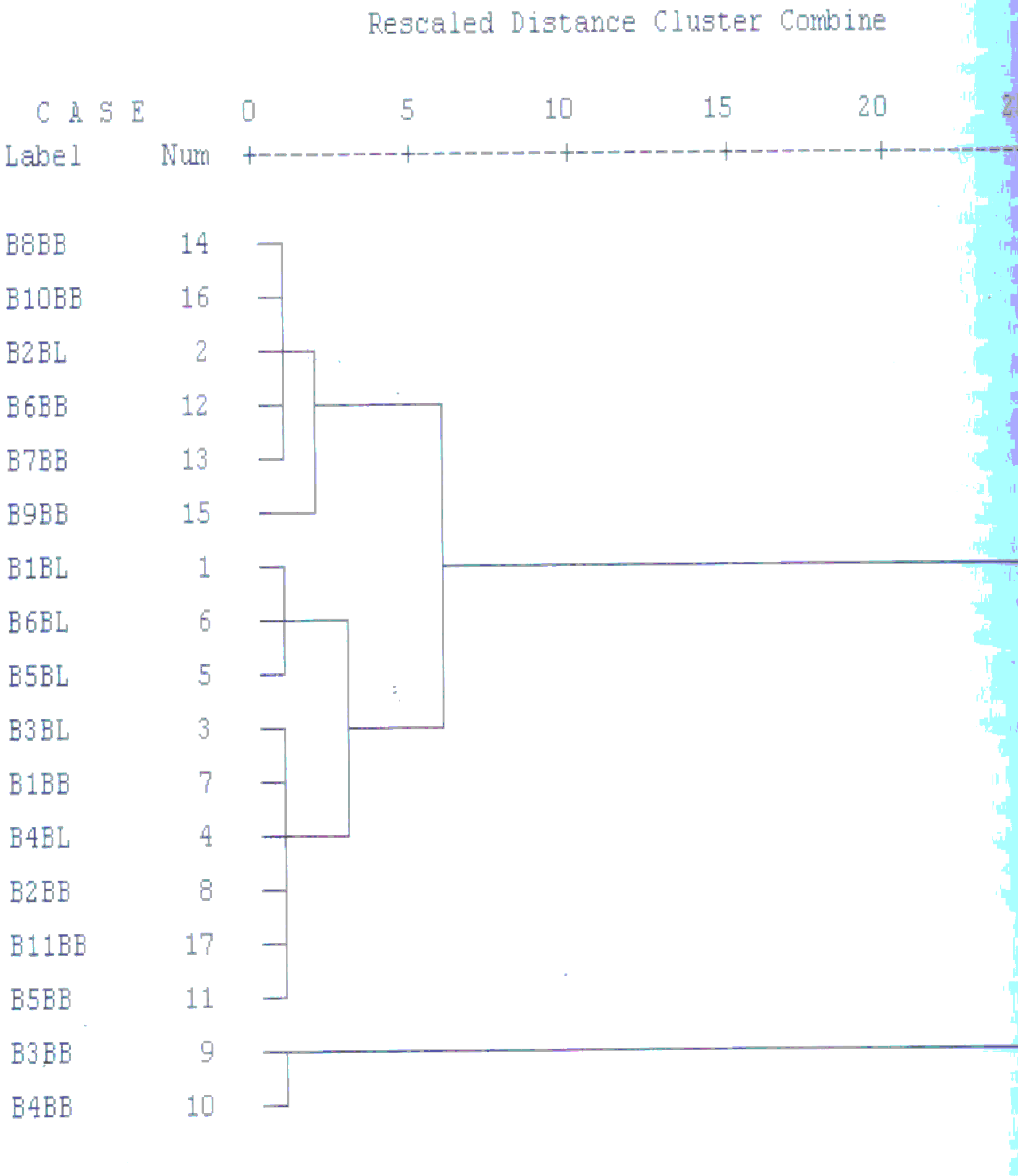

Fig.2 The similarity relationship characteristic of Chemical Physics Soil Characteristics Of Vegetation In Double Levee Area (Source : Windusari, 2012)

Table 1. Vegetation characteristics and environmental conditions in the tailings deposition area Double Levee

Table 1. Vegetation characteristics and environmental conditions in the tailings deposition area Double Levee

Block	Status area	Vegetation type	pH Of soil	C-organik (%)	N-total (%)	P (mg/kg)	K	Na	Ca	Mg	KTK	percentage of each soil particle size (%)		
									(cmol/kg)			<2 µm	2-53 µm	53-2000 µm
B1BL	Natural succession	Field of *P.karka*	7.87	0.63	0.10	4.88	0.19	0.23	5.32	1.55	6.81	3.08	42.64	54.24
B2BL	Natural succession	Padang *P. karka*	7.72	0.64	0.08	7.63	0.20	0.25	5.92	1.92	5.40	6.16	66.28	27.56
B3BL	Reclamation	Secondary forest	7.90	0.92	0.11	9.81	0.18	0.28	10.84	2.58	9.04	3.54	56.04	40.46
B4BL	Natural succession	Secondary forest	7.96	0.73	0.07	6.65	0.17	0.24	12.79	2.31	6.67	5.47	59.00	35.50
B5BL	Natural succession	Secondary forest	7.89	0.65	0.08	7.17	0.12	0.20	9.28	1.62	6.10	0.77	14.07	85.17
B6BL	Reclamation	Transition	7.83	1.04	0.12	7.45	0.20	0.27	15.64	1.98	7.43	5.45	63.40	31.10
B1BB	Natural succession	Transition	6.59	0.44	0.06	4.91	0.13	0.17	2.88	0.96	6.35	1.50	22.60	75.90
B2BB	Natural succession	Transition	6.95	0.60	0.07	6.52	0.18	0.31	9.53	1.83	2.85	0.35	4.75	94.90
B3BB	Natural succession	Transition	7.50	0.21	0.02	3.89	0.12	0.19	4.92	0.53	1.73	2.40	47.90	49.70
B4BB	Natural succession	Transition	7.50	0.44	0.05	3.72	0.20	0.24	2.05	1.58	2.26	3.70	66.55	29.75
B5BB	Natural succession	Transition	7.37	0.67	0.09	5.92	0.17	0.45	6.21	1.44	3.88	3.40	41.20	55.35
B6BB	Natural succession	Transition	7.84	0.58	0.06	4.82	0.16	0.31	4.95	1.19	3.02	6.15	70.25	23.55
B7BB	Natural succession	Transition	7.71	0.65	0.08	3.89	0.18	0.50	6.95	1.06	4.09	4.55	75.90	19.55
B8BB	Natural succession	Transition	7.74	0.49	0.05	4.49	0.17	0.24	7.70	0.93	3.55	10.55	57.20	32.25
B9BB	Natural succession	Transition	7.66	0.61	0.08	4.70	0.22	0.41	11.29	0.95	4.39	6.82	52.08	41.08
B10BB	Suksesi alami	Transition	7.70	0.94	0.10	4.67	0.23	0.53	11.67	1.58	7.66	4.16	38.67	57.19
B11BB	Natural succession	Transition	6.25	0.22	0.05	5.68	0.06	0.16	1.63	0.57	3.72	0.79	9.00	90.19
B12BB	Natural succession	Transition	7.50	0.67	0.06	4.50	0.22	0.41	6.29	0.96	3.35	6.82	52.08	41.08

Sources: Data field and Freeport and Environmental Laboratory (2009) at Windusari (2012)

CONCLUSION

Based on the discussions that have been raised above, it can be concluded that the characteristics of the succession of vegetation on the tailings deposition area is relatively stable (case of the Double Levee area), is characterized by the development of a short and tend to be fast growing species, and species composition of vegetation is affected by changes in soil chemical and physical conditions and higher species diversity in areas with fine particles.

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