International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Species Diversity of Undergrowth Vegetation in Former Silica and Limestone Mining Land at PT Holcim Indonesia Tbk, West Java Indonesia

Ceng Asmarahman[a*], Sri Wilarso Budi R[b*], Imam Wahyudi[c], Erdy Santoso[d]

[a]Graduate student, Silviculture Tropical Studies Program Graduate School of Bogor Agriculture University. Academic Ring Road, Campus IPB Dramaga. PO Box 168, Bogor, 16680, Indonesia, Division of Forestry, Faculty of Agriculture, Lampung University.

[b]Departement of Silvicultur, Faculty of Forestry. Bogor Agriculture University. Academic Ring Road, Campus IPB Dramaga. PO Box 168, Bogor, 16680, Indonesia.

[c]Departement of Forest Product, Faculty of Forestry. Bogor Agriculture University. Academic Ring Road, Campus IPB Dramaga. PO Box 168, Bogor, 16680, Indonesia.

[d]Senior Researcher at Microbiology Laboratory, Forest Research and Development Agency. Forest and Environment Ministry.

[a]Email: cengasmarahman@yahoo.com

[b]Email: wilarso62@yahoo.com

[c]Email: imyudarw16@yahoo.com

[d]Email: erdy_santoso@yahoo.co.id

Abstract

Open pit mining causes damage on ground cover vegetation, increase of erosion rate, decrease of land productivity, and decrease of soil fertility. Revegetation activity needs long period of time, so there is a need for planting of cover crops. The objective of cover crop planting is protecting soil from erosion.

---

* Corresponding author.

The objectives of this research were learning species composition, species diversity and potency of undergrowth vegetation to be utilized as cover crop. Composition of undergrowth vegetation in ex-limestone mining land was higher as compared with that in ex-silica mining land. Species diversity (H') in each research location was categorized as moderate. Species evenness (E) in the two research locations were categorized as high. Species richness (R_1) in the two research locations were categorized as high. Dominance index (C) in the two research locations were categorized as low. Soil properties in each location were categorized as not so fertile. Nutrient elements occurring in the two research locations were categorized as low.

Keywords: cover crop; species diversity; soil properties; undergrowth vegetation species.

1. Introduction

1.1. Background

Forest vegetation community could undergo change, either due to natural disaster or due to human activities. Human activities in the forest could be destructive or be beneficial for improving forest vegetation community. According to [12], destructive human activities comprise tree felling, forest products theft, illegal land cultivation, illegal grazing, forest fire and mining; whereas human activities which improve vegetation condition are revegetation for rehabilitation of bare land created after logging and fire, or revegetation for developing industrial plantation forest and reclamation of former mining land. Mining activity being conducted by PT Holcim Indonesia are mining of limestone and silica for cement raw materials. These mining activities are conducted as open pit mining by breaking and scraping off the upper layer of soils. According to [6], upper layer of soil being scraped is very sensitive to disturbance, because life existence is situated in horizon O, A and B. Negative impact of open pit mining activities cause damage on vegetation which cover the soil and hydrological system, increase of erosion rate, decrease of land productivity and stability, and decrease of soil fertility.

Therefore, reclamation which should be conducted on ex-mining land is revegetation activity. Revegetation activity needs considerable amount of time, so there is a need for soil cover crop before tree planting activities are conducted. Soil cover crops are plants which are planted to protect soil from damage threat created by erosion, and improving the physical and chemical properties of soil. One of the constraints in the use of *cover crop* in revegetation of ex-mining land is the availability of seeds of the cover crop. According to [3], cover crop seeds have not been much commercialized in Indonesia, and therefore, the seeds should be imported from abroad. Up to now, researches on soil and vegetation characteristics of ex-mining have been frequently conducted, but specific research on potency of undergrowth vegetation to serve as local cover crop are still rarely be conducted..

1.2. Objectives of the Research

The objectives of this research were learning the number of species, species diversity, and potency of undergrowth vegetation to serve as cover crop in ex- silica and limestone mining land at PT Holcim Indonesia Tbk.

2. Materials and Method

2.1. Research Period and Location

This research was conducted from November through December 2015. Data collection was conducted in ex-silica and limestone mining land of Narogong, subdistrict of Cileungsi, district of Bogor and ex-silica mining land of subdistrict of Cibadak, district of Sukabumi, at PT Holcim Indonesia Tbk.

2.2. Materials and Equipment

Equipment being used were measuring tape, pegs, tally sheet, wooden hammer for soil sample ring, soil sample ring, hoe, knife, large soil fork, plastic pocket for 1 kg content, alcohol 70%, scissor, label paper, large plastic, newspaper, wooden frame for herbarium, oven, writing materials, camera and guidebook for undergrowth vegetation identification. Materials being used for this research were undergrowth vegetation and soil samples.

2.3. Procedure of Data Collection

2.3.1. Determination of Observation Plots

Observation plots were made at two locations, namely ex-silica and ex- limestone mining land. Five observation plots were placed in each of the location under purposive sampling scheme. Total number of observation plots was ten.

2.3.2. Construction of Observation Plots for Undergrowth Vegetation

Construction of observation plot for undergrowth vegetation was done by using quadrat plot method on tract of land measuring 100 m x 100 m. In each research location there were made 5 plots, measuring 2 m x 2 m each, with distance between plots 40 m. Layout of observation plots is shown in Figure 1.

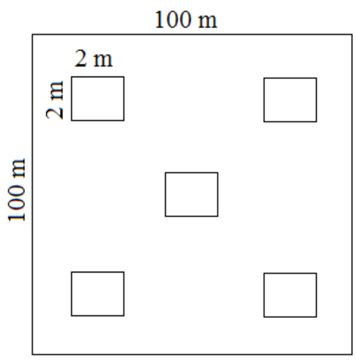

Figure 1: Observation plots for undergrowth vegetation

2.3.3. Herbarium Preparation and Species Identification

Herbarium preparation was conducted to identify undergrowth vegetation species which had not been identified in the field. Undergrowth vegetation specimens which had not been identified were processed into herbarium by drying them in oven at temperature of 150°C for 24 hours. Herbarium preparation and identification of undergrowth vegetation species was conducted in Laboratory of Ecology, Faculty of Forestry, IPB.

2.3.4. Collection of Soil Samples

Soil samples for chemical property analysis were taken from depth up to 20 cm, using hoe. Soil samples were taken from 5 points of observation plots in each research location. Afterwards, soil samples were composited and an amount of 1 kg was taken for analysis. Soil samples for physical property analysis were taken using ring soil sampler, as many as 4 rings. Soil sample rings were pressed until the ring bodies were buried into the soil. The buried soil rings which had contained the soil in natural condition, were taken out by using hoe. Afterwards, the lower part of the soil was made flat by slicing with thin sharp knife, and the intact condition of the soil samples were strictly maintained. Plots for soil sample collection were shown in Figure 2.

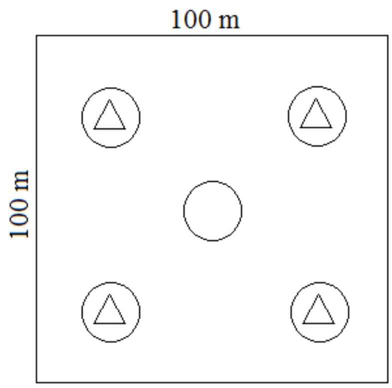

Figure 2: Plots for soil sample collection

Notes = Plots for chemical property soil samples

= Plots for physical and chemical property soil samples

2.4. Data Analysis

Data analysis for learning the composition and diversity of undergrowth plant species comprise vegetation analysis calculation which obtains Importance Value Index, Richness Index, Diversity Index and Species Evenness Index.

2.4.1. Importance Value Index

Importance Value Index (IVI) is a quantitative parameter being used to learn the dominance level of species in a vegetation community [12]. Formulas being used for determination of IVI values are as follows:

$$\text{Density (ind ha}^{-1}\text{)} = \frac{\text{number of individuals (ind)}}{\text{area size of all sample plots (ha)}}$$

$$\text{Relative Density (\%)} = \frac{\text{density of a species}}{\text{density of all species}} \text{ x } 100\%$$

$$\text{Frequency} = \frac{\text{Number of sample plots containing a particular species}}{\text{Number of all sample plots}}$$

$$\text{Relative Frequency (\%)} = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \text{ x } 100\%$$

$$\text{IVI (\%)} = \text{RD} + \text{RF}$$

2.4.2. Species Richness Index

Species richness index Margalef (R_1) is a calculation of species richness in a community. According to [16] a figure of R_1 <3.5 shows species richness which is categorized as low, R_1 between 3.5 and 5.0 was categorized as moderate, and R_1>5.0 was categorized as high.

$$R1 = \frac{S - 1}{\ln(N)}$$

whereas:

R_1 = Margalef index

S = Number of species

N = Number of all individuals

2.4.3. Species Diversity Index

According to [16], values of species diversity index are generally within a range between 1.0 and 3.5. If H' approaches 3.5 it indicates diversity level which is progressively higher.

$$H' = -\sum\left(\frac{ni}{N} \text{x} \ln\frac{ni}{N}\right)$$

whereas:

H'= Species diversity index

ni= Number of individual of i^{th} species

N= Number of all individuals

2.4.4. Species Evenness Index

Level of vegetation evenness in a community is shown by species evenness index. This evenness index shows the distribution of individuals in all species within a community. According to [16] a figure of E < 0.3 shows species evenness which is categorized as low, E between 0.3 and 0.6 shows species evenness which is categorized as moderate, and E > 0.6 shows species evenness which is categorized as high.

$$E = \frac{H'}{\ln(S)}$$

whereas:

E = Species evenness index

H' = Species diversity index

S = Number of species

2.4.5. Dominance Index

Dominance index is a parameter which shows the extent of centricity of species dominance in a community.

$$C = \sum \left(\frac{ni}{N}\right)^2$$

whereas :

C = Dominance index

ni = Number of individuals in i^{th} species

N = Number of individuals of all species

2.4.6. Community Similarity Index

Community Similarity Index (SI) is needed to learn the level of similarity between several stands, sampling units or communities, and to learn the comparison of composition and structure of the communities [12].

$$SI\ (\%) = \frac{2w}{a + b} \text{x } 100\%$$

whereas:

SI= Community Similarity Index

w= Summation of Importance Value Index (IVI) which are similar, or the lower value of species which are found in the two sample plots being compared

a= Summation of IVI in community A

b= Summation of IVI in community B

3. Results

3.1. Location and Geographic Position

PT Holcim Indonesia Tbk. is the largest cement producer in the world with production capacity of more than 170 million tons of cement . Holcim Indonesia operates cement factories in Narogong, Cilacap, Tuban and Sukabumi. PT Holcim which operates in Narogong is situated in Narogong area, Cileungsi subdistrict, Bogor regency with coordinates of 6°53’33” S and 106°27’37” E. PT Holcim which operates in Sukabumi is situated in Cibadak subdistrict, Sukabumi regency, with geographic location at coordinates 6°54’55” S and 106°46’39”E.

3.2. Physical Condition of the Environment

Topography of PT Holcim area which operates in Sukabumi possesses slopes which range between 40% – 60%. According to Schmidt and Ferguson classification (1951), this area possesses climatic type B with average temperature at wet months of around 21°C – 29.9°C, whereas temperature at dry months are around 21.6°C – 30.8°C. PT Holcim Tbk which operates in Narogong possesses average rainfall of 3 315 mm/year, which according to Schmidt and Ferguson classification (1951) possessed climatic type A. Rainy season occurs between October and April with highest rainfall occurs in Desember through February, whereas dry season generally occurs in May through September. Average humidity is 85.25%, the lowest humidity occurs in September (79%) and the highest humidity in December and January (89%). Soils occurring in the operation area of PT Holcim Tbk in Sukabumi comprise soil types Yellowish Red Latosol, Brown Latosol, Yellowish Red Podsolic and Lithosol. Soil type in PT Holcim which operates in Narogong is Lithosol.

3.3. Number of Species of Undergrowth Vegetation in Each Research Location

Number of undergrowth vegetation species was in general varied greatly in each ex-mining land of PT Holcim Indonesia Tbk. Number of undergrowth vegetation species found in ex- limestone mining land was 31 species from 20 families, whereas that in ex-silica mining land were found 22 species of undergrowth vegetation from 9 families. Total number of undergrowth vegetation species found in the two locations was as many as 51 species from 24 families. Comparison of number of species in each research location is presented in Figure 3.

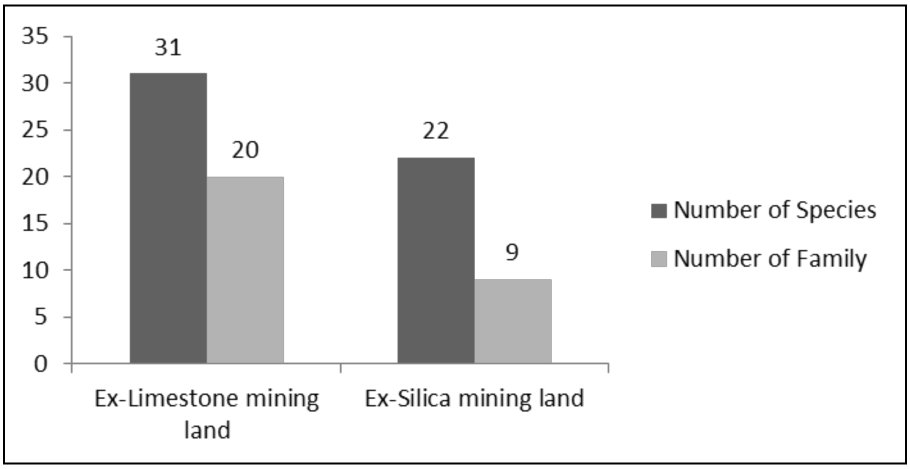

Figure 3: Number of undergrowth vegetation species in each research location

3.4. Dominance of Undergrowth Vegetation Species in Each Research Location

Undergrowth vegetation species occurring in ex-limestone mining land are shown in Table 1. Undergrowth vegetation species which possessed IVI greater than 10% in ex-limestone mining land were *Ageratum conyzoides* with IVI 10.34%, *Bidens pilosa* with IVI 10.79%, *Mimosa pudica* with IVI 14.91%, *Cyperus rotundus* with IVI 17.28% and *Eulesine indica* with IVI 38.08%.

Undergrowth vegetation species occurring in ex-silica mining land are shown in Table 2. Undergrowth vegetation species which possessed IVI greater than 10% in ex-silica mining land were species *Panicum paludosum* with IVI 10.41%, *Pennisetum polystachyon* with IVI 12.47%, *Mimosa pudica* with IVI 15.01%, *Calopogonium muconoides* with IVI 15.93%, *Paspalum cartilagineum with* IVI 17.05%, *Paspalum conjugatum* with IVI 19.76% and *Imperata cilindrica* with IVI 32.90%.

3.5. Diversity of Undergrowth Vegetation Species

Index values of diversity, richness, evenness and dominance of undergrowth vegetation species in each research location are presented in Table 3. Species diversity (H’) in each research location show values which are not much different from each other. Species evenness index (E) in ex-silica mining land is higher than that in ex-limestone mining land. Species richness index (R_1) in ex-limestone mining land is higher than that in ex-silica mining land. Dominance index (C) in ex-limestone mining land is 0.07, whereas that in ex-silica mining land is 0.11.

3.6. Community Similarity Index (SI)

Similarity Index describes the level of similarity of species composition between two communities being compared. Parameters being used to analyze similarity index is species abundance and presence of similar species. Values of similarity index between ex-limestone mining land and ex-silica mining land is low, namely 12.46%.

3.7. Soil Physical Properties

Results of soil physical properties in each research location are presented in Table 4. The observed soil physical properties were texture, bulk density, particle density, total pore space and permeability.

Table 1: Undergrowth vegetation species in ex-limestone mining land

No	Species name	Family	IVI (%)	Notes*)
1	Eleusine indica	Poaceae	38.08	Invasive
2	Cyperus rotundus	Cyperaceae	17.28	Invasive
3	Mimosa pudica	Fabaceae	14.91	Invasive
4	Bidens pilosa	Asteraceae	10.79	Invasive
5	Ageratum conyzoides	Asteraceae	10.34	Invasive
6	Spigelia anthelmia	Loganiaceae	8.46	Invasive
7	Centella asiatica	Apiaceae	8.03	Non Invasive
8	Paspalum vaginatum	Poaceae	7.91	Invasive
9	Gendarussa vulgaris	Acanthaceae	6.34	Non Invasive
10	Phyllanthus urinaria	Phyllanthaceae	6.32	Non Invasive
11	Lindernia anagallis	Linderniaceae	5.79	Non Invasive
12	Amaranthus spinosus	Amaranthaceae	5.79	Invasive
13	Imperata cylindrica	Poaceae	5.62	Invasive
14	Fimbristylis aphylla	Cyperaceae	4.92	Non Invasive
15	Isachne globosa	Poaceae	4.92	Non Invasive
16	Digitaria ciliaris	Poaceae	4.76	Invasive
17	Phyllanthus debilis	Phyllanthaceae	4.24	Non Invasive
18	Brachiaria paspaloides	Gramineae	3.91	Invasive
19	Paspalum commersonii	Poaceae	2.66	Invasive
20	Sida rhombifolia	Malvaceae	2.43	Invasive
21	Vigna trilobata	Fabaceae	2.35	Non Invasive
22	Hydrolea zeylanica	Hydrophyllaceae	2.27	Invasive
23	Bergia capensis	Elatinaceae	2.27	Invasive
24	Oxalis barrelieri	Oxalidaceae	2.27	Invasive
25	Aeschynomene indica	Fabaceae	2.27	Invasive
26	Mikania micrantha	Asteraceae	2.20	Invasive
27	Ipomoea triloba	Convolvulaceae	2.20	Invasive
28	Portulaca oleracea	Portulaceae	2.20	Invasive
29	Mimosa invisa	Fabaceae	2.12	Invasive
30	Euphorbia heterophyllaa	Euphorbiaceae	2.12	Invasive
31	Cardiospermum halicacabum	Sapindaceae	2.12	Non Invasive

*) Notes: SEAMEO BIOTROP 2008

Table 2: Undergrowth vegetation species occurring in ex-silica mining land

No	Species name	Family	IVI (%)	Notes*)
1	Imperata cylindrica	Poaceae	32.90	Invasive
2	Paspalum conjugatum	Poaceae	19.76	Invasive
3	Paspalum cartilagineum	Poaceae	17.05	Invasive
4	Calopogonium muconoides	Fabaceae	15.93	Non invasive
5	Mimosa pudica	Fabaceae	15.01	Invasive
6	Pennisetum polystachyon	Poaceae	12.47	Invasive
7	Panicum paludosum	Poaceae	10.41	Invasive
8	Mimosa invisa	Fabaceae	9.57	Invasive
9	Echinochloa stagnina	Poaceae	8.62	Invasive
10	Ischaemum ciliare	Poaceae	7.43	Non invasive
11	Ishaemum rugosum	Poaceae	6.63	Non invasive
12	Paspalum longifolium	Poaceae	6.51	Invasive
13	Calopogonium polytscyon	Fabaceae	6.24	Non invasive
14	Melastoma malabathricum	Melastomataceae	4.25	Invasive
15	Ischaemum timorense	Poaceae	4.25	Non invasive
16	Tridax procumbens	Asteraceae	3.85	Invasive
17	Lycopidium clavantum	Lycopidium	3.65	Non invasive
18	Clidemia hirta	Melastomataceae	3.25	Invasive
19	Ludwigia hyssopifolia	Onagraceae	3.06	Invasive
20	Bacopa procumbens	Scrophulariaceae	3.06	Non invasive
21	Oxalis barrelieri	Oxalidaceae	3.06	Invasive
22	Crotalaria retusa	Fabaceae	3.06	Non invasive

*) Notes : SEAMEO BIOTROP 2008

Table 3: Vegetation species diversity in each research location

Location	H'	R1	E	C
Ex-limestone mining land	2.46	4.05	0.72	0.07
Ex-silica mining land	2.47	3.38	0.80	0.11

Table 4 shows that soil in ex-silica mining land possessed textural class sandy clay loam, dominated by high amount of sand, namely 58%. Soil in ex-limestone mining land possessed textural class *sandy clay loam*, dominated by high amount of sand, namely 46%. *Bulk density* (BD) in ex-silica mining land (1.23 $g\,cm^{-3}$) is higher than that in ex-limestone mining land (1.07 $g\,cm^{-3}$). *Particle density* (PD) in ex-silica mining land (2.40 $g\,cm^{-3}$) is higher than that in ex-limestone mining land (2.31 $g\,cm^{-3}$). Total pore space in in ex silica mining land (54.75 %) is higher than that in ex-limestone mining land (46.75 %). Value of WC in ex-silica mining land (25.88% vol) is higher than that in ex-limestone mining land% (25.33% vol).

Permeability in ex-limestone mining land (6.96 cm hour^{-1}) is higher than that in ex-silica mining land (2.99 cm hour^{-1}).

Table 4: Analysis results of soil physical properties in each research location.

Research location	Texture			BD[1)]	PD[1)]	TPS[*)]	WC[*)]	Permeability[*)]
	Sand	Silt	Clay					
	.... %			.... $g\ cm^{-3}$..........			% vol	cm hour^{-1}
Ex-limestone mining land	46	23	31	1.07	2.31	46.98 %	25.33	6.96
Ex-silica mining land	58	14	28	1.23	2.40	54.75 %	25.88	2.99

Notes : BD = *Bulk density*, PD = *particle density*, TPS = Total Pore Space,

WC = Water content. [*)] Average from 4 replications

3.8. Soil Chemical Properties

Chemical soil properties being analyzed were among others soil pH, soil organic matter, available P, cation exchange capacity and base saturation.

Analysis results for soil chemical properties of pH, organic matter and available P, are presented in Table 5.

Table 5: Analysis results for soil pH, organic matter, and available P in each research location

Research location	pH		Organic matter			Available P	
	H_2O	KCl	C	N	C/N	Bray	Olsen
			.... %			ppm	
Ex-limestone mining land	8.4	7.8	0.98	0.07	14		25
Category[*)]	SA	SA	VL	VL	M		L
Ex-silica mining land	5	4.9	0.75	0.08	9	7.8	
Category[*)]	A	A	VL	VL	L	VH	

Notes : A = Acid, SA = Slightly Alkaline, L = Low, M = Moderate, VL = Very Low, VH = Very High

[*)] Source : Juknis Analisis kimia tanah, tanaman, air, dan pupuk (Balai Penelitian Tanah Departemen Pertanian 2005)

Table 5 shows that value of soil pH in ex-limestone mining land is categorized as slightly alkaline, whereas that in ex-silica mining land is categorized as acid.

Table 6: Analysis results of cation exchange values and base saturation in each research location

Research location	Cation exchange values					BS
	Ca	Mg	K	Na	KTK	
	.... cmolc kg^{-1}....................					%
Ex-limestone mining land	44.5	1.18	0.16	0.13	18.79	>100
Category*)	VH	M	L	L	M	VH
Ex-silica mining land	1.48	0.48	0.08	0	8.82	23
Category*)	VL	L	L	L	L	L

Notes : R = Low, S = Moderate, SR = Very Low, ST = Very High, CEC = Cation Exchange Capacity ; BS = Base Saturation.

*) Source : Juknis Analisis kimia tanah, tanaman, air, dan pupuk (Balai Penelitian Tanah Departemen Pertanian 2005)

Table 6 shows that soil in each research location contained magnesium element which was categorized as moderate; and nitrogen, phosphorus and potassium which were categorized as low. Calcium content in ex-limestone mining land was categorized as very high, whereas that in ex-silica mining land was categorized as very low. Cation exchange capacity in ex-limestone mining land was categorized as moderate, whereas that in ex-silica mining land was categorized as low. Base saturation in ex-limestone mining land was categorized as very high, whereas that in ex-silica mining land was categorized as low.

4. Discussion

4.1. Number of Species of Undergrowth Vegetation

Number of species of undergrowth vegetation in ex-limestone mining land was greater than that in ex-silica mining land. This was probably due to the open condition of the land, without any shade tree, resulting in greater abundance of undergrowth vegetation in the ex-limestone mining land. Research by [11] showed that land which was lightly shaded, possessed greater number of undergrowth vegetation species, as compared with land which was heavily shaded. This research results were in agreement with statement of [12] which said that trees with dense shade caused the sunlight to be unable to penetrate into forest floor, and hence did not allow development of undergrowth vegetation under the tree shade, except for plant species which has adapted properly to grow under shade.

The small number of species of undergrowth vegetation in ex-silica mining land was probably due to existence of pine trees which had been planted there. Allelopathic compound originated from pine probably affected species composition of undergrowth vegetation. According to [15], pine trees produces alelopathic compound which retard nitrogen accumulation, so that plant growth would also be retarded due to inability to absorb nitrogen optimally.

4.2. Dominance of Plant Species

Importance Value Index (IVI) indicates the importance of a particular species in a community. Species which possesses the highest IVI constitutes the dominant species [8], explained that a species has a great role in a community if the IVI value of the species is more than 10% for undergrowth vegetation. There were two species of undergrowth vegetation which were the most dominant in ex-silica and limestone mining land, namely *Imperata cylindrica* and *Eulesine indica* which belong to family Poaceae. These species were originated from Tropical America, and in Indonesia they have been uniformly spread to all regions [8]. The two species of undergrowth vegetation probably possessed high adaptation capability which made them able to grow in ex-limestone and silica mining land.

4.3. Species Diversity of Undergrowth Vegetation

Species richness index (R_1), species diversity (H') and species evenness (E) give a quantitative description on diversity of a community. The use of species richness index in assessing diversity is aimed at learning the number of species found in a community. Based on classification [16] the R_1 value of undergrowth vegetation occurring in ex-limestone mining land, was categorized as moderate, whereas richness index of ex-silica mining land was categorized as low. Difference in species richness in the two locations was affected by the number of species being found in the research locations. Based on classification [16], species diversity indices (H') in each research location was categorized as moderate. This phenomenon was affected by mining activities in the two locations, so that the environment was disturbed and caused little occurrence of undergrowth vegetation. Species evenness indices (E) in each research location were categorized as high.

Reference [13] explained that dominance index is an indicator of the extent a particular species being dominant in a community. Dominance index which approach 1 is categorized as high, and implies that the dominance is centered on one or several few species. On the other hand, if the dominance index approaches zero, it is categorized as low and implies that the dominance is spread on many species. Based on calculation results, dominance indices in the two locations were categorized as low, which imply that the dominance of undergrowth vegetation species in the two research locations were spread in many species.

4.4. Species Similarity Index (SI)

Species similarity index describes the level of similarity between several communities. Reference [13] explained that if the IS value < 75%, the two communities being compared were considered different; while if IS ≥ 75%, the two communities were considered similar. Value of SI obtained from the two locations shows that there were fairly significant difference between the two locations in terms of undergrowth vegetation composition. This difference was probably affected by environmental factors such as soil condition, rainfall and slope.

4.5. Potency of Undergrowth Vegetation as Cover Crop

Cover crops are plants which grow densely and are deliberately planted to protect and improve soil [1]. Cover crops could play some role in controlling and preventing erosion. Cover crop could directly slow down the fall of rain water, reduce the speed of surface runoff and encourage the development of soil biota which could improve soil physical and chemical properties [18].

Characteristics of cover crop for revegetation activities are easy to be planted, fast growing, able to perform symbioses with beneficial bacteria or fungi, able to produce abundant biomass which is easily decomposed, not competing with the main crop and not twining around the main crops [5].

Analysis results of undergrowth vegetation shows that undergrowth vegetation which is most suitable to be developed as *cover crop* is species *Calopogonium mucunoides*, because this species is not invasive and available in large quantity in ex-silica mining land. Besides the species *C. mucunoides,* undergrowth vegetation which have potential to serve as *cover crop* are species *Centella asiatica, Gendarussa vulgaris, Phyllanthus urinaria, Lindernia anagallis, Fimbristylis aphylla, Isachne globosa, Phyllanthus debilis, Vigna trilobata, Cardiospermum halicacabum, Crotalaria retusa, Bacopa procumbens, Lycopidium clavantum, Ischaemum timorense, Calopogonium polytscyon, Ishaemum rugosum,* and *Ischaemum ciliare.* Those species are probably able to serve as cover crop because they are not invasive. However, the number of species of such undergrowth species was only small in the research location, probably due the effect of invasive undergrowth vegetation species existing in the area. Undergrowth vegetation species *Eleusine indica, Imperata cylindrica, Paspalum conjugatum, Paspalum cartilagineum, Ageratum conyzoides, Cyperus rotundus,* and *Mimosa pudica* posses IVI value >10%, but they were probably not suitable to be developed as cover crop because those species are categorized as invasive species [2].

4.6. Analysis of Soil Physical Properties

Soil with clayey texture has more ability to hold water than soil with sandy texture, and this is related with the area size of adsorptive surface. The finer the texture, the greater would be the capacity to hold water [10]. Soils with loam texture are considered as soil with high organic matter content and are optimal for plant growth because the soil's capacity to hold water and nutrients are better than those of sandy soil, and their drainage and aeration are better than those of clayey soils [17].

Bulk density (BD) is a measure of the amount of soil mass per unit of volume, expressed in $\mathrm{g\,cm^{-3}}$ [23]. The more compact the soil, the greater would be the BD, which implies that the more difficult would be the soil to let the water flow through it. The BD values of mineral soil usually range between 1.1 $\mathrm{g\,cm^{-3}}$ and 1.6 $\mathrm{g\,cm^{-3}}$. Soil analysis results on BD shows that BD values in the two research location belonged to low category because the BD were smaller than 0.90 $\mathrm{g\,cm^{-3}}$. These values of soil BD show that in soils of each research location there were instability of soil structure due to mining activities and compaction by the use of heavy equipment during mining process.

Particle density (PD) is the ratio between the dry mass of soil solid particles and their volume. This volume does not include the pore space existing between the particles. Values of PD are affected by component of mineral materials and organic materials of the soil. Values of mineral soil PD generally range between 2.60 $g\ cm^{-3}$ and 2.70 $g\ cm^{-3}$ [22]. Soil PD in ex-silica mining land was lower than that in ex-limestone mining land. This was due to difference in content of organic matter. According to [22], the higher the organic matter content, the lower would be the PD.

Total Pore Space (TPS) of soil constitutes the portion of soil occupied by water and air. Soil TPS is closely related with BD. According to [23], increase in BD caused decrease in TPS. Soil TPS in ex-silica mining land was higher than that in ex-limestone mining land, due to relatively low BD in ex-silica mining land. Water content in ex-limestone mining land was higher than that in ex-silica mining land.

Permeability is the soil's ability to let water pass through the soil body under saturated condition. Generally, permeability is measured as rate of water flow through soil body within a period of time and is generally expressed in unit of *cm hour*^{1} [20]. Permeability in ex-limestone mining land and ex-silica mining land were consecutively slightly rapid and moderate. Soil ability to hold water is affected by soil texture. Soil with fine texture will hold more water as compared with that of coarse texture. Therefore, soils with sandy texture are easy to suffer drought which could disturb plant growth .

4.7. Analysis of Soil Chemical Properties

Lost of topsoil is an indication of poor soil fertility in ex-mining land. According to [4], constraint in ex-cement raw material mining land area, is the lack of essential nutrients, such as nitrogen and phosphorus and toxicity due to extreme soil pH (soil pH which is too low or too high).

Soil reaction indicates soil acidity as expressed as soil pH. Soil pH is very important to determine the ease of nutrient absorption by plants, and also to detect the possibility of toxic elements in soil [9]. Soil pH in ex-silica mining land was acidic, whereas soil pH in limestone mining land was slightly alkaline. Plants in acid soil are unable to absorb element P because the element is tightly held by element Al in the soil. In alkaline soil, plants are unable to absorb element P because the element is tightly held by Ca in soil. Acid soil pH could be increased by adding lime, whereas alkaline soil pH could be reduced by adding sulfur [9].

Content of organic C and total N in each research location was categorized as low, whereas ratio of C/N was categorized as low and moderate. According to [23] organic matter plays an important role in soil quality. Decrease in soil organic C indicates decrease in soil quality. Soil organic matter affects soil ability to hold and supply nutrients and water for plants, encourages and maintains root growth, creates suitable habitat for soil biota and resists soil degradation.

Content of available P constitutes the soil P which is soluble in water and nitric acid. Soil pH could be used as a standard measure to compare the results of soil P test. Olsen method is usually used for soils which have pH larger than 5.5, whereas Bray method is used for soils which have pH less than 5.5 (Umaternate and his colleagues 2014). Based on assessment of soil chemical properties [7], P contents in ex-silica and ex-limestone mining land were consecutively categorized as low and very low. Low P content in ex-silica mining land was probably affected by soil pH which was categorized as acid, whereas low P content in ex limestone mining land was probably affected by alkaline soil pH. Low P content could retard plant growth due disturbed cell division.

Cation Exchange Capacity (CEC) is soil chemical property which is closely related with soil fertility because soils will not be able to hold nutrients and supply them to plant if the CEC is low [9]. Result of soil chemical property analysis for CEC in ex-silica mining land was categorized as low, whereas that in ex-limestone mining land was categorized as moderate. According to [19], low CEC would cause stagnant growth of plant. The magnitude of CEC is affected by several factors, such as amount of clay and organic matter, and soil pH [19].

Content of Ca in ex-silica mining land was categorized as low, whereas Ca content in ex-limestone mining land was categorized as very high. This condition was created by parent material in the soil. In ex-limestone mining land, the very high Ca content was due to the limestone parent material of the soil. Contents of elements Mg, K and Na in each research location were categorized as ranging from low to moderate, and even element Na in ex-silica mining land was found to be very little in soil, so that the content value was zero. Macro nutrients (Ca, Mg, K and Na) which are available in little amount in soil could cause abnormality in plant growth.

Base saturation (BS) in ex-silica mining land was categorized as low. This condition was in agreement with research result of [21], where the base saturation in ex-silica mining land was low because the soil pH was categorized as acid. This phenomenon was also in agreement with [25] which explained that BS is linearly related with soil pH. If the soil pH is low, the base saturation will also be low. Base saturation in ex-limestone mining land was categorized as very high, and this was probably due to content of limestone parent material in the soil, so that the base saturation was high.

5. Conclusion

Total number of species of undergrowth vegetation found in each research location of PT Holcim Indonesia Tbk was as many as 51 species from 24 families, distributed in ex-limestone mining land as many as 31 species, and in ex-silica mining land as many as 22 species. Species diversity level of undergrowth vegetation in each research location was categorized as moderate. Species which exhibited the highest IVI in ex-silica mining land and ex-limestone mining land were *Imperata cylindrica* and *Eulesine indica*. Undergrowth vegetation which are suitable to be developed as cover crop was species *Calopogonium mucunoides.*

References

[1] [Kementerian Kehutanan]. 2011. Peraturan Menteri Kehutanan Republik Indonesia Nomor: P.4/Menhut-II/2011 tentang Pedoman Reklamasi Hutan. Jakarta (ID): Kementerian Kehutanan.

[2] [SEAMEO BIOTROP] Southeast Asian Regional for Tropical Biology. 2008. Invasive Alien Species Database. [internet]. [diunduh pada 25 Juni 2016]. Tersedia pada : http://www.biotrop.org/database.

[3] Arafat NI. 2015. Pertumbuhan Desmodium heterophyllum (Willd.) DC. Sebagai tanaman penutup tanah di lahan bekas tambang silika [skripsi]. Bogor: Fakultas kehutanan, Institut Pertanian Bogor.

[4] Asir LO. 2013. Alternatif teknik rehabilitasi lahan terdegradasi pada lahan bekas galian industri. J. Balai Penelitian Kehutanan Manado. 1 (1): 9-17.

[5] Dariah A, Abdurachman A, Subardja D. 2010. Reklamasi lahan eks penambangan untuk perluasan areal pertanian. Jurnal Sumberdaya Lahan. 4 (1): 1-12.

[6] Darwo. 2003. Respon pertumbuhan Khaya anthoteca Dx. DA, Acacia crassicarpa, A. Cunn. Ex. Benth. Terhadap penggunaan endomikoriza, pupuk kompos dan asam humat pada lahan pasca penambangan semen [tesis]. Bogor: Institut Pertanian Bogor.

[7] Eviati, Sulaeman. 2009. Analisis Kimia Tanah, Tanaman, Air, dan Pupuk. Bogor (ID): Balai Penelitian Tanah.

[8] Gustiani A. 2015. Pola penyebaran jenis kapasan kuning (Thespesia lampas Dalz and Gibs) di savana bekol Taman Nasional Baluran [skripsi]. Bogor: Institut Pertanian Bogor.

[9] Hardjowigeno S. 2003. Klasifikasi Tanah dan Pedogenesis. Jakarta (ID): Akademika Pressindo.

[10] Haridjaja O, Baskoro DPT, Setianingsih M. 2013. Perbedaan nilai kadar air kapasitas lapang berdasarkan metode alhricks, drainase bebas, dan pressure plate pada berbagai tekstur tanah dan hubungannya denngan pertumbuhan bunga matahari (Helianthus annus L.). J.Tanah dan Lingkungan. 15 (2): 52 – 59.

[11] Hilwan I, Mulyana D, Pananjung WG. 2013. Keanekaragaman jenis tumbuhan bawah pada tegakan sengon buto (Enterolobium cyclocarpum Griseb.) dan trembesi (Samanea saman Merr.) di lahan pasca tambang batubara PT Kitadin, Embalut, Kutai Kartanagara, Kalimantan Timur. Jurnal Silvikultur Tropika. 04 (01):6 – 10.

[12] Indriyanto. 2008. Ekologi Hutan. Jakarta (ID): PT Bumi Aksara.

[13] Istomo, Kusmana C. 1997. Penuntun Ekologi Hutan. Laboratorium Ekologi Hutan. Bogor (ID): Fakultas Kehutanan, Institut Pertanian Bogor.

[15] Kunarso A, Azwar F. 2012. Keragaman jenis tumbuhan bawah pada berbagai tegakan hutan tanaman di Bekanat Sumatera Selatan. Jurnal Penelitian Hutan Tanaman. 10 (2):85 – 98.

[16] Magguran. 2004. Measuring Biological Diversity. Oxford (UK): Blackwell Science Ltd.

[17] Mahmud, Wardah, Toknok B. 2014. Sifat fisik tanah di bawah tegakan mangrove di Desa Tumpapa Kecamatan Balinggi Kabupaten Parigi Moutong. J. Warta Rimba. 2 (1):129 – 135.

[18] Maisyaroh W. 2010. Struktur komunitas tumbuhan penutup tanah di taman hutan raya R. Soerjo Cangar, Malang. Jurnal Pembangunan dan Alam Lestari. 1 (1): 1-9.

[19] Oktavia D, Setiadi Y, Hilwan I. 2014. Sifat fisika dan kimia tanah di hutan kerangan dan lahan pasca tambang timah Kabupaten Belitung Timur. Jurnal Silvikultur Tropika. 05 (3):149 – 154.

[20] Pratiwi EF. 2014. Karakteristik fisika tanah pada beberapa penggunaan lahan di tanah latosol darmaga dan podsolik jasinga [skripsi]. Bogor: Fakultas Pertanian, Institut Pertanian Bogor.

[21] Pudjiharta A, Santoso E, Turjaman M. 2007. Reklamasi lahan terdegradasi dengan revegetasi pada bekas tambang bahan baku semen. Jurnal Penelitian Hutan dan Konservasi Alam. IV (3):223 – 238.

[22] Ritonga IWS. 2015. Pengaruh konversi lahan hutan terhadap sifat fisika tanah (studi kasus : Desa Tugu Utara, Kecamatan Cisarua, Bogor) [skripsi]. Bogor: Fakultas Pertanian, Institut Pertanian Bogor.

[23] Subandiono RE, Suryani E, Subardja D. 2014. Sifat – sifat tanah pada lahan potensial untuk pengembangan pertanian di Provinsi Jambi dan implikasi pengelolaannya. J. Tanah dan Iklim. 36(1):1 – 51.

[24] Umaternate GR, Abidjuju J, Wuntu AD. 2014. Uji metode olsen dan bray dalam menganalisis kandungan fofat tersedia pada tanah sawah di Desa Konarom Barat Kecamatan Dumoga Utara. Jurnal Mipa UNSTRAT. 3(1):6 – 11.

[25] Wilson, Supriadi, Guchi H. 2015. Evaluasi sifat kimia tanah pada lahan kopi di Kabupaten Mandailing Natal. Jurnal Online Agroekoteknologi. 3(2): 642 – 648.