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Towards Welfare and Environmental Sustainability

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TABLE of CONTENT

Title Page i
Preface iii
Table of Content iv
Keynote Speaker

Tohru Mitsunaga (Gifu University, Japan)
Introduction Of Natural Products Chemistry Obtaining From
Cooperative Researches Using Indonesian Plants 1

Kuniyoshi Shimizu
Molecular Target Of Triterpenoid With Anticancer Activity Isolated
From Medicinal Mushroom, *Ganoderma lingzhi* 2

PAPER

A. WOOD PROPERTIES AND BIODEGRADATION

Widi Sunaryo (Faculty of Agriculture, Mulawarman University)
Co-expression Analysis of Genes Associated with Cambial Cell Differentation during
Wood Formation 4

Harry Praptoyo (Faculty of Forestry, Gadjah Mada University)
The effect of Methyl Jasmonate Hormone to Stimulate the Formation
of Traumatic Resin Duct in Pines (*Pinus merkusii* Jungh et de Vriese) from KPH Lawu DS 10

Tibertius Agus Prayitno (Faculty of Forestry,Gadjah Mada University)
Properties of Heat Treated Teak Wood from Community Forest 17

B. BIOCOMPOSIT AND TIMBER ENGINEERING

Bakri (Faculty of Forestry, Hasanuddin University)
Application of Carbon Dioxide Injection Technology in Bamboo Cement Board Production................... 25

James Rilatupa (Faculty of Engineering, Christian University of Indonesia)
Gypsum Board and Cement Board As An Acoustic Material For Building 32

Johannes Adhijoso Tjondro (Parahyangan Catholic University)
The flexural strength and behavior of cross laminated timber floor.. 40

C. BIOENERGY AND FOREST PRODUCT CHEMISTRY

Ganis Lukmandaru (Faculty of Forestry, Gadjah Mada University)
Quinones Distribution in Juvenile Teak Wood 47

Wahyu Dwiyanto (Indonesian Institute of Sciences)
Enzymatic Saccharification and Ethanol Production of Xylems from
Indonesian Botanical Garden Tress 55

Ika Fikriah (Faculty of Medicine, Mulawarman University)
A Review: Screening of Potency Akar Kuning Stem (*Fibrauerea tinctoria* Lour)
as Antimalarial Combination Therapy 60

Rini Pujiarti (Faculty of Forestry, Gadjah Mada University)
Insecticidal Activity of *Melaleuca leucadendron* Oil against Greenhouse Whitefly
Trialeurodes vaporariorum 65

Gina Saptiani (Faculty of Fishery and Marine Sciences, Mulawarman University)
Potential of *Acanthus ilicifolius* Extract To Diseases ReducedOn Prawn 71

D. GENERAL FORESTRY

Avry Pribadi (Balai Penelitian Teknologi Serat Tanaman Hutan)
Potency Usage of Plantation Forest of *Acacia mangium* and *Acacia crassicarpa*as
Source of Honeybee Forage and Its Problem 76

Wahjuni Hartati (Faculty of Forestry, University of Mulawarman)
Study on Land Rehabilitation at Mined Lands of PT Trubaindo Coal Mining,West Kutai,
East Kalimantan (2011 – 2012) 80

POSTER PRESENTATION

Rattana Choowang (Faculty of Science and Technology Prince of Songkla University, Thailand)
Influence of vascular bundles population on basic density and mechanical properties
of oil palm wood (*Elaeis guineensis* Jacq.) 99

WissaneeYingprasert (Faculty of Sciences and Industrial Technology,
Prince of Songkla University, Thailand)
The investigation of the bondability of the Ethylene Gaseous stimulated rubberwood 103

Akapong Petharwut (Faculty of Sciences and Industrial Technology,
Prince of Songkla University, Thailand)
Potential of boron rubberwood preservatives against Asian subterranean
termite *Coptotermes gestroi* (Isoptera: Rhinotermitidae) 109

Ganis Lukmandaru (Faculty of Forestry, Gadjah Mada University)
Antitermitic Activites of Bark Extracts of Teak Wood 112

Triyani Fajriutami (R&D Unit for Biomaterials, Indonesian Institute of Sciences (LIPI)
Microwave-Assisted Acid Hydrolysis of Sugarcane Bagasse Pretreated with White-Rot Fungi 118

Study on Land Rehabilitation at Mined Lands of PT Trubaindo Coal Mining, West Kutai, East Kalimantan (2011 - 2012)

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Abstract

In many cases, mined lands is not immediately ready to support plant growths due to bad drainages, soil structure disturbances, high temperature, uncontrollable overland flow, high erosion rate, lack understanding of suitable plant species, planting techniques and its maintenance. The study objective is to find out applicable design - procedure - techniques of mined-out lands revegetation to support and accelerate the ecological recovery of mined-out lands. Land revegetation is conducted by planting 10 trees species (3.000 seedlings) at mined-out lands after reclamation works. Plants species are selected based on previous studies and expected ecological function. Plant height, diameter, and growth performance are used as parameters associated with physical and chemical soil characteristics. The plant growth percentage is 93% with the lowest of *Artocarpus champedens* (84%) and the highest of *Peronema canescens* (86%) consecutively. Moreover, *Terminalia catappa*, *Annona muricata*, and *Muntingia calabura* show the strongest growth performance, while *Shorea balangeran*, *Artocarpus champedens*, *Pterocarpus indicus* are found weak. Soil is found being high compacted but no significant difference of fertility status between upper and lower layers, and also recognized being acid with moderate CEC and very high base saturation. Organic fertilizing reduces soil compactness, increasing soil porosity, CEC and its water content. Fertilizing of 100g NPK (16-16-16) stimulates biggest diameter and height increments of *Shorea balangeran*, *Terminalia catappa*, *Annona muricata*, *Ficus variegata*, *Schima walichii*. Moreover, *Shorea balangeran*, *Entrolobium cyclocarpum*, *Terminalia catappa*, *Annona muricata*, *Ficus variegata*, *Schima walichii*, *Peronema canescens*, and *Muntingia calabura* are still responsive to fertilizer application. Considering low nutrients contents, chemical fertilization are still needed to immediately increase macro nutrients content. Suggested dosage of NPK (16-16-16) fertilizer is 100 gr for *Entrolobium cyclocarpum*, *Peronema canescens*, *Muntingia calabura*, *Terminalia cattapa*, and *Schima walichii*; 150 gr for *Annona muricata*, *Ficus variegata*, *Shorea balangeran*; and 50 gr for *Pterocarpus indicus* and *Artocarpus champedens*. Simultaneously with revegetation works, the phenomenon of soil erosion potential dynamic is depend on influencing factors upon soil erosion occurences that are rainfall erosivity, soil erodibility, landform slope-lengths, vegetation cover, practical soil and water conservation. Vegetation growth cover is the most significant factor related with soil erosion dynamic at revegetated mined-out lands.

Keywords: *mined-out lands*, *lands rehabilitation*, *physical-chemical soil characteristics*, growth *percentage*, *tree species, soil erosion potential*

Introduction

Background

The utilization of natural resources and environmental management have to be conducted properly to minimize its negative impacts into environments, in order being possible to retain quality and sustainability of natural resources for pepoples welfare. PT Trubaindo Coal Mining (TCM) as one of leading coal mining company strongly efforts to monitor and manage all potential - on going - predictable arising negative impacts due to coal mining activities. Coal mining activities causes a significant environmental impacts related over lands slope stability, hydrology, environmental pollution, natural resources decreasing, infiltration rate and capacity, vegetation covers dissapear, topsoils removal, wildlife and its habitat, peoples health, social economic disparities ect. Therefore coal mining activities have to be followed by maximum efforts in line with its standar operating procedures of lands clearing, topsoils management, mining waste treatments, water resources monitoring, mined-out lands restoration - reclamation - revegetation and other important efforts related with coal mining operation.

A part of working area of PT TCM is located at production forest area based on borrow-use pattern permit earned from Ministry of Forestry, and therefore PT TCM has a mandatory obligation to rehabilitate its mined-out lands to be rocovered into productive lands of production forest area in the future. The achievement of mined-out lands rehabilitation needs a proper knowledge and field experiences especially focused in soils and lands dynamic, reclamation-rehabilitation techniques, species site matching based on specific government rules, and also lands preparation, planting techniques and its vegetation maintenances.

PT TCM applies open pit/cast method of mining operation started with general preparation followed by land clearing - topsoils striping and removal - blasting - over burden opening and coal mining. However, considering that coal mining is a kind of non-renewable resources utilization, it must be fully considered to the principles of rational - efficient, and as far as possible to minimize the environmental impacts and disturbances in the spirit of keep an enough stock for next generation. Moreover, it is also well known that application of open pit mining system causes landscape changes and at the same time influencing *bio - geo - physics - chemical characteristics* changing, social-economic-culture and health of peoples. For this reason, it is needed to prepare and anticipate of all countermeasure efforts in relation with sustainable capacity of environmental for supporting peoples life and welfares.

Rehabilitation of Mined-out Lands

As a part of environmental setting and management planning which is effective and efficient, mined-out lands rehabilitation have to be done following the technical method and procedures explained at documents of Environmental Impact Assesment, Monitoring, and Environmental Management Plans. Land clearing have to be followed by field practical works relating to lands rehabilitation efforts. Removed topsoils as about 30cm should be temporarily placed at designed site surrounding mining operation area and later on to be replaced at the top of reclamied sites to support plant growth of lands revegetation.

Topsoils stockpile is protected with dykes in order for not being eroded by surface runoff during rainy days. To make sure that lands rehabilitation after open mining system could be performed, mined-out lands have to followed by backfilling whether in our out pit dump immediately. Moreover, concerning to the coal seam position and its slope, specific method of contour mining, area mining and panel mining are applied by PT TCM. Mined-out lands reclamation - reshaping and recontouring are conducted at each block consecutively and at the end all of block are completed. Both of mining water and rainfall which are flowing as surface runoff and potentially transporting mass mud are controlled and directed into catchpond/settling pond for mud sedimentation.

Open pit system causes decreasing lands surface and new disposal of over-burden and inter-burden. To reduce such mass dumping disposals, these materials are then used to fill former pit. As backfilling is completed generally is directly followed by slope and drainage works to avoid increasing and uncontrollable surface runoff. Finally, this reclamation works is continued by spreading of topsoils and therefore ready for revegetation works. Revegetation works is initiated by land cover crops to minimize potential soil erosion. Legume plants is used to accelerate soil fertilization and followed by tree planting with selected plants of fast growing species. After cover crops and fast growing species plants are growing well, it is possible to conduct enrichment planting by using selected tree species based on some considerations such as lands status, economically productive trees, and also ecpected ecological role for supporting life system.

General Characteristics of Mined-out Lands

As mentioned before, open pit system produces a mass disposal of over-burden and inter-burden which is then used to fill mined-out pits. After backfilling process, most of dumping materials is in condition of wreak or disturbed structure and pores and could be a mass of unstable dumping materials. Moreover, some time also unavoidably mixed with dirty coal and off course almost without any organic material. This condition lead to a bad drainage and low water holding capacity, highly compacted and difficult to be penetrated by plant roots, opening space and high temperature.

Problem Formulation

Regarding to lands rehabilitation through reclamation and revegetation activites, the main problem is that backfilled mined-out lands not fully ready to support plants growth due to bad drainage, disturbed soil structure and also relatively high land temperature. Subsequently, uncontrollable high overland flow followed by high soil erosion rate, fragmented soil materials, soil mixed with fine coals and lack of organic materials are also have to be properly treated before planting. In relation with planting, species site matching (trees, land cover crops), planting techniques and its procedures for maintenance are also still needed to be solved. So far, the results of mined-out lands revegetation has not been satisfy as expected especially in species diversity due to plants species still limited to monoculture species.

Study Objective and Expected Results

The main objective of this research is focused to develop design, procedurs, techniques, and the successfulness of mined-out lands revegetation. Therefore, the results of this reseach is expected to be one of important consideration to implement many efforts in ecological function recovery, economics and social aspects of forest areas post coal mining actvities.

Study Methodology

Study Site and Research Period

The study of mined-out lands reabilitation is conducted at the coal concession of PT TCM Site Adong, West Kutai, East Kalimantan. Panoramic view of the rest forested area is shown at **Photo-01** as representative of surrounding mined-out lands. The green spots of forested area shows a good forest with natural regeneration with high density ranging 3.000 - 5.000 seedlings per hectare with identified species of *Shorea parvifolia*, *Dipterocarpus cornutus*, *Shorea ovalis*, *Shorea ochracea*, and *Shorea superba*.

Photo-01.View of Original Forest Vegetation Surrounding Mined-out Lands of PT TCM, West Kutai, East Kalimantan

Regarding to government acts in forestry, the status of study site area is a non forest area (KBNK) with a massive destruction post mining operation. Administratively, the site is located at West Kutai regency as a part of East Kalimantan Province. Geographically, all of coal consession area of PT TCM is lying at the coordinate of 0°27’44’’ - 0°51’41’’ South and 115°30’00’’ - 115°51’ 30”East.

Research Procedures

The research is performed during arround two years (June 2011 - December 2012) covering of documentation and refferences study, field data collections, data organization, analysis and reporting. Field observation and measurement are performed into diameter, height, and physical field performance of plant growth. The soil chracteristics and soil erosion potential are also studied simultaneously with the efforst of reclamation and revegetation of mined-out lands.

Photo-02. View of Study Area - Reclamation of Mined-out Lands of PT TCM, West Kutai, East Kalimantan

Study Site

The study of mined-out lands rehabilitation is conducted at Block-2 Ex-Pt with ± 6 hectares large in area. Before this study, earthworks was done in this location such as ex-pit back filling, re-contouring, re-shaping and topsoils spreading. The final result of these earthworks is a landscape with 8-15% slope as viewed at **Photo-02**.

Plants Species

The plants used for field planting trial in this study are consisting of ten species that are S01-*Shorea balangeran* (Kahoi), S02-*Artocarpus champedens* (Cempedak), S03-*Entrolobium cyclocarpum* (Sengon Butho), S04-*Terminalia catappa* (Ketapang), S05-*Pterocarpus indicus* (Angsana), S06-*Annona muricata* (Sirsak), S07-*Ficus variegata* (Kondang), S08-*Schima walichii* (Puspa), S09-*Peronema canescens* (Sungkai), serta S10-*Muntingia calabura* (Kersen/Cherry). Plants materials of several species are shown at **Phto-03** of which **e**ach species as much as 25 individual plants.

Photo-03. Several Plant Species for Mined-out Lands Revegetation Work

Repetition of Plants Species

The experimental design for data collection and analysis of field observation and measurement results is done by using completely randomized design. This experimental design is used by considering available location for study, accessibilty and supporting facilities. Moreover, the sum of repetition for each species is 3 (three) following randomization and requirement for statistical analysis reason.

Soil Treatment on Planting Holes

This research is also perform 4 (four) soil treatments of T1, T2, T3 and T4. T1 is regular treatment done by PT TCM in their mined-out lands rehabilitation and therefore is used as benchmark for other treatments of this research (**Table-01**). Planting pattern is 3 m x 3 m and as much as 25 invidual plants are planted at each compartment (PUC) for each species.

Table-01. Soil Treatment Applied at Mined-out Lands Rehabilitation of PT TCM

Treatment	Organic Fertilizer (kg)		Dolomite (kg)		NPK Fertilizer (g)	
	Per-plant	Total	Per-plant	Total	Per-plant	Total
Year 2011	**First Year**					
T2	20	15.000	0,5	375	50	37.500
T3	20	15.000	0,5	375	100	75.000
T4	20	15.000	0,5	375	150	112.500
Total		45.000		1.125		225.000
Year 2012	**Second Year**					
T2	10	7.500	0,5	375	50	37.500
T3	10	7.500	0,5	375	100	75.000
T4	10	7.500	0,5	375	150	112.500
Total				1.125		225.000

Note: Number of Plant/Treatment = Σ Species (10) x Σ Plant/PUC (25) x Repetition (3) = 750

Design of PUC

The layout of PUC is made as long as following the availability of mined-out lands in the field (**Figure-01**). For statistical reason, the placement of PUC completely is randomized which based on repetition (U), soil treatments (T) and its plant species (S) as shown at **Table-02**. Each PUC is quadrangle of 15 m x 15 m in shape or 225 m^2 in area and therefore the study area of mined-out land is 120 x 225 m^2 = 29.700 m^2 or 2,97 hectares large in area.

Table-02. Randomization of PUC at Mined-out Lands Revegetation

No.	PUC	No.	PUC	No.	PUC	No.	PUC	No.	PUC
001	U2T2S06	025	U2T3S01	049	U2T1S06	073	U2T2S09	097	U3T4S09
002	U2T4S01	026	U2T1S04	050	U1T3S09	074	U1T2S05	098	U1T2S04
003	U3T1S03	027	U2T3S04	051	U2T4S02	075	U3T1S10	099	U1T4S06
004	U2T2S04	028	U3T3S05	052	U1T2S09	076	U2T4S10	100	U2T2S07
005	U1T3S02	029	U1T4S08	053	U1T4S07	077	U2T2S03	101	U1T2S06
006	U1T1S10	030	U1T4S05	054	U3T4S01	078	U3T1S05	102	U2T4S04
007	U1T4S04	031	U1T3S03	055	U2T3S10	079	U2T4S09	103	U3T4S07
008	U3T4S02	032	U1T1S01	056	U3T4S03	080	U3T3S10	104	U2T4S08
009	U2T1S01	033	U3T3S02	057	U2T1S03	081	U1T3S10	105	U1T2S07
010	U1T1S02	034	U3T3S06	058	U2T3S05	082	U3T2S03	106	U2T3S09
011	U3T2S09	035	U2T2S02	059	U1T4S09	083	U1T1S08	107	U1T1S06
012	U2T1S07	036	U1T3S05	060	U3T3S09	084	U3T2S04	108	U3T1S08
013	U1T1S03	037	U3T1S09	061	U1T2S01	085	U3T4S04	109	U1T2S08
014	U3T1S02	038	U2T2S01	062	U3T4S06	086	U2T4S05	110	U3T4S08
015	U2T1S10	039	U2T2S05	063	U2T3S08	087	U3T3S08	111	U1T3S04
016	U1T3S08	040	U3T1S01	064	U3T3S04	088	U2T2S10	112	U3T2S06
017	U2T1S05	041	U1T2S02	065	U1T4S03	089	U2T4S06	113	U2T4S07
018	U3T3S01	042	U3T1S07	066	U2T1S08	090	U3T4S10	114	U3T2S08
019	U1T3S01	043	U3T2S01	067	U3T4S05	091	U3T2S07	115	U2T3S03
020	U2T1S02	044	U1T2S03	068	U3T1S06	092	U1T4S02	116	U1T1S07
021	U1T1S05	045	U1T4S10	069	U2T3S06	093	U1T1S09	117	U1T3S07
022	U3T3S03	046	U2T3S02	070	U3T1S04	094	U2T3S07	118	U1T1S09
023	U1T4S01	047	U3T2S02	071	U2T4S03	095	U2T2S08	119	U3T2S05
024	U1T1S04	048	U3T2S10	072	U1T3S06	096	U3T3S07	120	U1T2S10

Measurement of Plant Height and Diameter

The plant diameter and height are used as qunatitative parameter for plant growth percentage. Plant height is measured by scaled wooden stick while diameter measurement is done by using micro-caliper and plastic metline scale. Both of measurement are using centimeter scale.

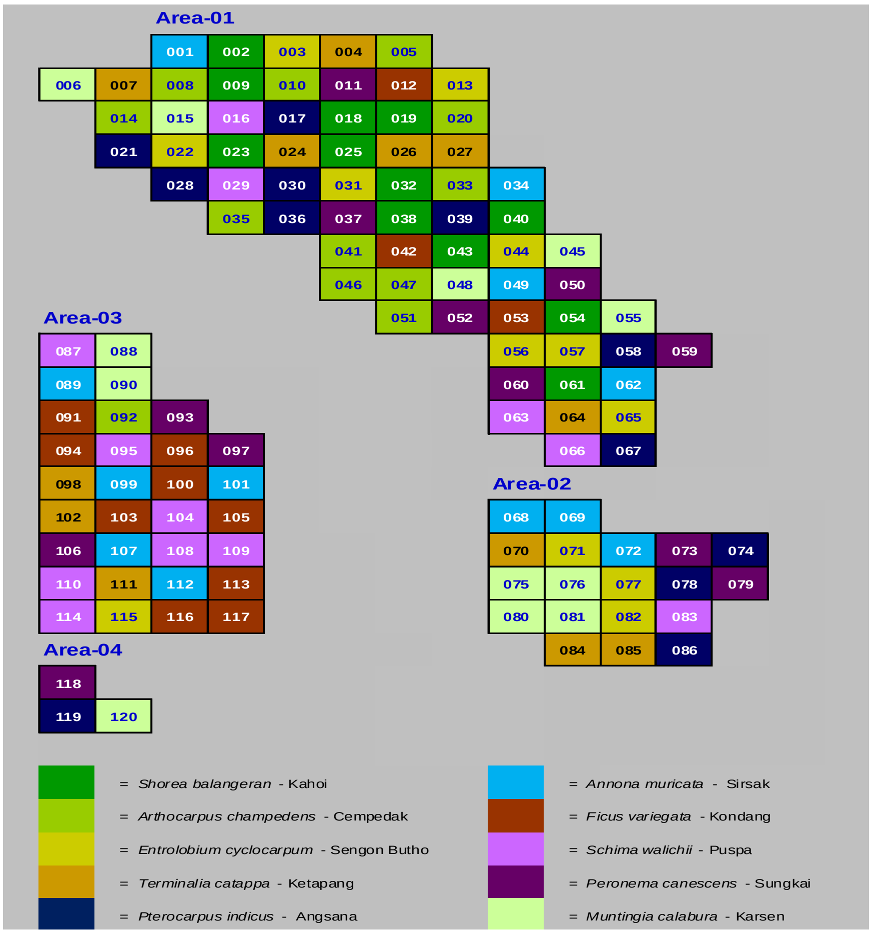


Figure-01.Layout Distribution of Plant Species at Mined-out Lands

Result and Discussions

Description of Study Site

Geographycal Position

The coal mining concession of PT TCM is 23.650 hectares and located at West Kutai, East Kalimantan. Travelling throughout provincial way connecting Samarinda City to study site needs about 7 (seven) hours. Meanwhile, using river transportation in about 16 (sixteen) hours travelling along Mahakam River. Geographically, all of coal consession area of PT TCM is lying at the coordinate of 0°27’44” - 0°51’41” South Latitude and 115°30’00” - 115°51’ 30” East Longitude.

Geology

Geological condition covering study site shows two existing major synclines of North and South areas. Northern area consist of North and East blocks, while in Southern area are Dayak Besar, Nage, Biangan, Perak, and Lati blocks in which prospective mined coal seam is in layer group between 1.700 - 9.300. The slope of coal seam is in 20° - 50° ranging and distributed in several geological formation. Variation of lithology covere coal seam consist of sandstone and silstone, and the rock structure has been indicated as Miocene to Holocene. The rock structure is a repetition of sandstone-siltstone-coal with formation depth more than 4.000 m in form of syncline in the direction to West-South and East-North. Average coal quality indicates a gross calorific value of 6.400-6.600 Kcal/kg in North Block, 6.100-7.600 Kcal/kg in South Block and more than 7.000 Kcal/kg for East Block. In general, the ash content is low with high variation of sulphure. The coal potential is about 33,7 MT (North), 28,t MT (Dayak Besar), and 34,5 MT (Biangan).

Climate

According to Climate Classification System of Schmidt and Ferguson (1951), the study site is under influence of A type (very wet) indicated by Q = 0. Annual rainfall is 3.832 mm with monthly average of 319 mm, highest in April (463 mm) and the lowest in August (171 mm) followed by mean evapotranspiration 1.795 mm/year or about 150 mm/month. The monthly maximum air temperature 34,6°C and minimum 21,8°C with average of 27,8°C. Subsequently, monthly average of relative humidity is ranging 83,0-87.0% with average 85,9%. Monthly wind velocity is 7,2 m/sec. highest in May (12,9 m/sec.) and lowest in July (3,6m/sec.). Using rainfall - evapotranspiration approach, water deficit is in September as much as 89,3 mm but in overall is still surplus of water as much as 1.579 mm/year or in about 131,7 mm/month.

Vegetation

Based on the results of environmental impact assesment document of PT TCM, it is known that the diversity of plant stage, seedling - sapling - pole - tree is relatively high. For seedlings, the dominant species are *Mellastoma sp* (Karamunting), *Macaranga triloba* (Mahang), *Piper aduncum* (Siri-siri), *Macaranga retiniodes*, and *Eurycoma longifolia* (Pasak Bumi). Moreover for sapling stage are *Mellastoma sp* (Karamunting), *Macaranga triloba* (Mahang), *Macaranga gigantea* (Bingkungan), *Ptelocolobium dulce* (Petai hutan), and *Octomeles sumatrana* (Binuang bini). For pole stage are *Macaranga triloba* (Mahang), *Vitex pubescens* (Laban), *Arenga pinata* (Aren), and *Eugenia sp* (Jambu-jambuan). For tree stage is dominated by species of *Peronema cenescens* (Sungkai), *Vitex pubescens* (Laban), *Arthocarpus elasticus* (Terap), *Gluta renghas* (Rengas), and *Trigonopleura malayana*.

Mined-out Lands Rehabilitation

Mined-out lands rehabilitation has to be conducted in relation with environmental management efforts to recover ecological soil function. PT TCM has been keeping the mission to create an added value of rehabilitated mined-out lands by planting several multipurpose trees species which is not only for ecological function but also trying hard to increase economic value by planting local tree species. Land reclamation itself is performed in several steps as topsoils removal-ex-pit backfilling-recontouring-reshaping-topsoils spreading. Subsequently, lands revegatation is performed through lands preparation-planting-maintenance to support plants growth. Since 2006, PT TCM has been a lot of lands rehabilitation works pattern by planting cover crops and primary species such as Gmelina, Rubber, Bananas.

Plants Species - Planting Tecchnique - Maintenance

The plants used for field planting trial in this study are consisting of ten species that are *Shorea balangeran*), *Artocarpus champedens*, *Entrolobium cyclocarpum*, *Terminalia catappa*, *Pterocarpus indicus*, *Annona muricata*, *Ficus variegata*, *Schima walichii*, *Peronema canescens*, *Muntingia calabura*. All of plant materials are prepared by Researcher and also PT TCM. Planting holes, organic fertilizer and dolomite application were done by personels of Rehabilitation Section (RS) of PT TCM. Subsequently, measurement and plant maintenance are also performed by RS.

Plants Growth Percentages

In overall, ten plant species with 300 plant individu for each and therefore as much as 3.000 plant individu were planted in third week of October 2011. Based on field observation, it is obtained that growth percentage of plant is ranging at 66% (Cempedak) to 98% (Kondang). In overall 3.000 plant 84% is survived. From 3.000 planted plants, the survive plants including replantted plants is 2.525 individu (84%) with lowest survival Cempedak (66%) and Sirsak (70%), while Sengon butho, Ketapang, Angsana and Kondang are higher than 90%.

Plant Growth

This study uses ununiform plants material of 1-2 years age with relative tall height and young age of 3 months with small size plants due to limited availability of expected species. Aged plants material are Cempedak, Sengon, Kondang, dan Sungkai; and the small plants material are Ketapang, Angsana, Sirsak, Puspa, and Kersen. Considering the ununiformity assessment of plants increament (height and diameter) is expressed in relative value. Plants species classified fast in growth are Sengon butho, Angsana, Sirsak, Kondang and Kersen wich recorded 1.000% diameter increament compared to initial diameter. Moreover, plants species is fast in height increament are Ketapang, Sirsak and Kersen which is recorded 7-9 times increament higher compared with initial height.

Table-03. Plant Species and Performance at Mined-out Lands Rehabilization in 19 December 2012

No	Species	Survive	Dead	Diameter (cm)		Height (cm)		Rd (%)	Rh (%)	Performance	(%) Survive
				(10/2011)	(12/2012)	(10/2011)	(12/2012)				
01.	Kahoi	239	61	0,53	1,92	134,12	119,20	262	-11	62	80
02.	Cempedak	199	101	0,40	1,81	86,76	112,00	353	29	62	66
03.	S-butho	290	10	0,44	12,88	90,73	490,42	2.827	441	38	97
04.	Ketapang	272	28	0,47	4,72	16,87	182,28	904	980	39	91
05.	Angsana	274	26	0,28	6,14	65,78	295,67	2.093	349	48	91
06.	Sirsak	209	91	0,14	2,79	14,25	130,55	1.893	816	47	70
07.	Kondang	294	6	0,45	7,28	82,96	288,01	1.518	247	40	98
08.	Puspa	239	61	0,21	1,99	21,70	98,07	848	352	49	80
09.	Sungkai	227	73	0,46	4,04	56,96	168,80	778	196	42	76
10.	Kersen	282	18	0,29	7,36	37,85	333,13	2.438	780	45	80
	Total	**2.525**	**475**								
	Total	**3.000**									

Using physical strong performance expressed in height-diameter ratio limit = 80, all of species can be categorized to be strong. However after 14 months planting, the ratio decrease under 50% except Kahoi and Cempedak. Both of these species is found to grow well. The value of height-diameter ratio limit in 2011 is 212% and 177% consecutively and in 2012 decrease to be 62%. The main cause of this condition is to much longer in nursery with uncomfort situation and hard competition of light for growing. At the end of 2012, all of plants spcies show a prospective growth. The biggest growth diameter and height is owned by Sengon butho.

Initial Soil Condition

Bulk density is ratio of dry soil mass weight to soils volume including soil pores that indicates the soils compaction and therefore more bigger means more compact soils. In general the value of bulk density is ranging between 1,1 - 1,6 g/cc (Hardjowigeno, 2003). Soils is quiet compact indicated by average of bulk density 1,69 g/cc in the range of 1,51 - 1,80 g/cc. The total pores shows that most of soils volume is mineral and organic materials (± 64%) and only 36% can be filled with air and/or water. Normally, about 50% of mineral soils volume is filled with air and/or water and other 50% are mineral and organic materials, and therefore soils compaction must be reduced and increasing soils pores for supporting plants growth. The common way to increase the proportion of mineral and organic materials is by adding soils organic materials due to an enough organic materials in the soils could make a better condition and plants roots can penetrate the soils even in a low available soils water as generally found at mined-out lands. The initial view of mined-out lands before planting works is shown at **Photo-05** and the detail of physical and chemical soils characteristics is figurized in **Table-04**.

Photo-05. View of Mined-out Lands After Lands Reclamations Works and Lands Preparation for Revegetation Works

The laboratory analysis on chemical soils characteristics show that no significant difference of soil fertility status between upper and lower soils layers. Both of these layers are found being acid with N, P, K very low, moderate CEC while base saturation is very high. This condition indicates that a high cations absorbtion lead to fertilizers being not leached easily following water percolation. High base saturation denotes that soils is dominated by base cations (Ca, Mg, K, NH4, Na), which is good for plants growth due to these cations are needed in a large amount to support plants growth. Conversely, an acid soils and a very low N, P, K contents should be improved by adding dolomite and NPK fertilizer application.

Table-04. Physical-Chemical Soisl Characteristics at PUC of Mined-out Lnds Rehabilitation

Description	BD (g/cc)	Total Pores (%)	pH H_2O	Nitrogen (%)	Carbon (%)	P_2O_5	K_2O	CEC	BS	Al Available
Soil Layer	**00 - 30 cm**									
Mean	1,69	36,36	4,92	0,05	0,69	7,57	6,66	16,78	74,5	25,5
Maximum	1,80	43,19	6,60	0,13	4,39	15,30	17,14	31,40	100,0	60,5
Minimum	1,51	32,06	4,30	0,02	0,21	4,96	2,85	9,32	39,4	0,0
Deviation	0,07	2,74	0,54	0,02	0,68	2,34	3,51	5,74	13,8	13,8
Criteria	-	-	**A**	**VL**	**VL**	**VL**	**VL**	**M**	**VH**	**M**
Soil Layer	**>31 - 60 cm**									
Mean	-	-	5,24	0,06	0,82	8,59	7,93	15,93	74,2	25,8
Maximum	-	-	7,40	0,11	3,30	23,98	20,74	27,47	100,0	73,2
Minimum	-	-	4,20	0,02	0,15	3,93	3,11	5,40	26,8	0,0
Deviation	-	-	0,88	0,02	0,77	4,24	4,99	4,73	20,8	20,7
Criteria	-	-	**A**	**VL**	**VL**	**VL**	**VL**	**M**	**VH**	**M**

Note: A = Acid, VL = Very Low, M = Moderate, VH = Very High

Soil Charateristics Improvement

In many crops culture, soils characteristics improvement is performed as soils show a decline function being media for plants growth. In this case, soils fertility based chemical characteristics is used as a refference to improve it's soils characteritics as nutrients source for plants. Similar to chemical characteristics, if it was found an unfavourable physical soils characteristics, it is also need to be improved in order root systems able to absorb nutrients for plants growth. **Table-04** shows that both of chemical and physical soils charateristis status are in bad condition and therefore considered to be improved whether before and after plantings.

Soil Acidity (pH)

There are a lot of soils characteristics being worse due to low soil acidity compared with the favourable range for plants growth as neutral acidity. In neutral range acidity, most of nutrients are easily soluted into water and also easily absorbed by plants. A lot of Aluminium ion is found at acid soils due to Phospor ion fixation and being toxic to plants. And also, micro nutrients are easily soluted at acid soils reaction and will be accumulated. In the condition of soil acidity close to neutral, the maximum avaliable phospor and micro nutrients solubility will decline. The bactery is well developed at pH 5.5 or more and will restricted at lower pH 5.5. The nitrogen fixation bactery and nutrification bactery are only develop at pH 5.5 or more, and therefore addition of dolomite should be applied at acid soils.

Reffering to **Table-04**, both of average pH at upper (4.92) and lower (5.24) soils layer are found to be acid. To increase pH is done by adding dolomite two weeks before planting with the amount based on exchangable Aluminium (e-Al). Dolomite addition as much as 1.5 e-Al is able to nuetralize 85-90% e-Al containing 2-7% organic materials. If soils contain a higher organic materials, dolomite should more be added due to ion H^+ released by organic materials or Fe and Al hydroxide. **Table-04** also shows that organic materials is categorized to be low (0.69%) and therefore added dolomite is 1.5 e-Al or equal to 0.5 kg/plant. In relation with base saturation which is categorized to be high, dolomite application might be not a proper aplication, however it is rather than soils nutrients defficiency but due to high soils acidity. Soil acidity improvement is indicated by increasing pH in both upper (0-30 cm) and lower (>30-60 cm) soil layers whereas the initial acidity status is acid (A) and changed into neutral (N) (**Figure-02**).

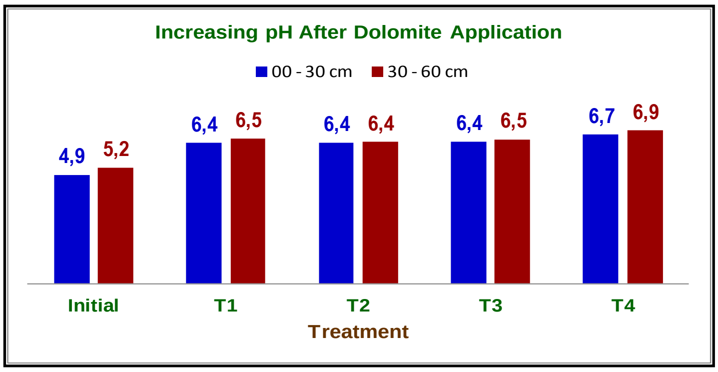


Figure-02. The Increase of Soil pH 14 Months After Dolomite Application

<u>Macro Nutrients Content</u> (N, P, and K)

The content of N, P, and K nutrients are very low and therefore applied with complex fertilizer of NPK (16:16:16) in a dosage of 50 g, 100 g, 150 g per plant. NPK (16:16:16) is applied after plants reach 3 months in age, which is aimed to make a nutrients balance of plant requirements and the need of immediate additional nutrients to support vegetative growth at the initial plant growth. The form of N of which imediately able to be used by plants is anorganic N supplied by chemical fertilizer. Organic decomposition produces humus will increase cation and anion absorption capacity. Moreover, absorbed cations and anions are not easily lost by leaching process and easy to be relased when they are needed by plants. The more available humus leads to a more efficient of soils fertilization.

Table-05. Macro Nutrients Content (N, P, and K) Post Fertilizer Application

No.	Nutrients	Initial	Post Fertilizer Application			
			(T1)	(T2)	(T3)	(T4)
Upper Soil Layer (00-30 cm)						
01.	Nitrogen (%)	0,05	0,04	0,03	0,05	0,04
02.	Phospor (ppm P_2O_5)	7,60	21,70	27,40	30,60	27,60
03.	Kalium (ppm K_2O)	6,70	60,90	49,70	63,70	64,30
Lower Soil Layer (>30-60 cm)						
04.	Nitrogen (%)	0,06	0,05	0,04	0,05	0,06
05.	Phospor (ppm P_2O_5)	8,60	29,80	23,40	30,00	32,50
06.	Kalium (ppm K_2O)	7,90	59,90	45,80	61,30	74,50

In case of N, there is no increase of it's content in one year after soils fertilization of all treatments, even for T1, T2, and T4 the content of N is lower than before soils fertlization. In most of all treatments except T1, the content of P and K increase in line with soils fertilization in a dosage of 50 g, 100 g, 150 g per plants. The P and K contents at T1 are obtained similr with T3. In spite of the fetrilization is done at the soils upper layer of ± 10 cm depth but the influence reach until lower soils layer (**Table-05**).

<u>Soil Bulk Density</u>

Soils compaction is indicated by bulk density (BD) value, the more bigger BD means more compact soils and therefore roots is likely difficult to penetrate into soils of which also difficult to make a better water drainage. Lands preparation using heavy equipments tends to disturb soils structures and reduce soil pores. Soil pores itself is influenced by organic materials content, soil structres and textures. Soil structures formation is significantly influenced by the existing organic materials bounding soil particles. To reduce the soil compaction, soil improvement is performed by adding organic compos as much as 20 kg at the initial satage before planting and 10 kg at one year after. Soil compaction monitoring shows a decreasing compaction of which indicated by it's bulk density.
Soils Improvement and Plants Growth

Diameter Increament

The influence of treatments on to biggest diameter increament of each species can be described that Sengon butho, Ketapang, Puspa, Sungkai, and Kersen are at T3, while Kahoi and Kondang at T4. Other species of Cempedak and Angsana at T1 and T2 (**Figure-03**) and the field performance can be seen at **Photo-05**.

S-01 - *Shorea balangeran* (Kahoi)

September 2011	December 2011	September 2012	December 2012

S-02 - *Artocarpus champedens* (Cempedak)

September 2011	December 2011	September 2012	December 2012

S-03 - *Enterolobium cyclocarpum* (Sengon Butho)

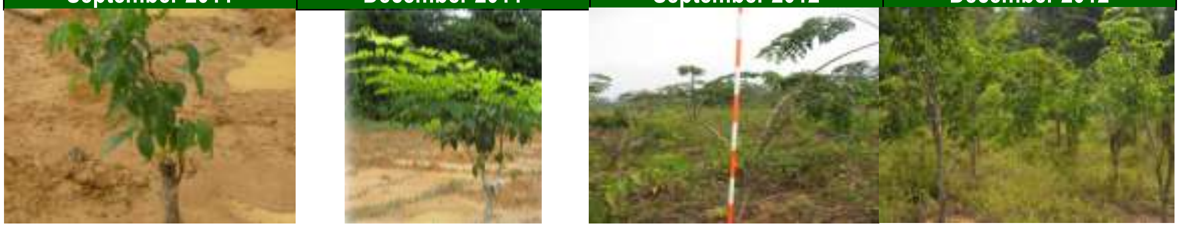
September 2011	December 2011	September 2012	December 2012

S-04 - *Terminalia catappa* (Ketapang)

September 2011	December 2011	September 2012	December 2012

S-05 - *Pterocarpus indicus* (Angsana)

September 2011	December 2011	September 2012	December 2012



S-06 - *Annona muricata* (Sirsak)

September 2011	December 2011	September 2012	December 2012

S-07 - *Ficus variegata* (Nyawai)

September 2011	December 2011	September 2012	December 2012

S-08 - *Schima walichii* (Puspa)

September 2011	December 2011	September 2012	December 2012

S-09 - *Peronema canescens* (Sungkai)

September 2011	December 2011	September 2012	December 2012

S-10 - *Muntingia calabura* (Kersen)

September 2011	December 2011	September 2012	December 2012

Photo-05. View of Plant Height Increament at Study Site of PT TCM, West Kutai, East Kalimantan

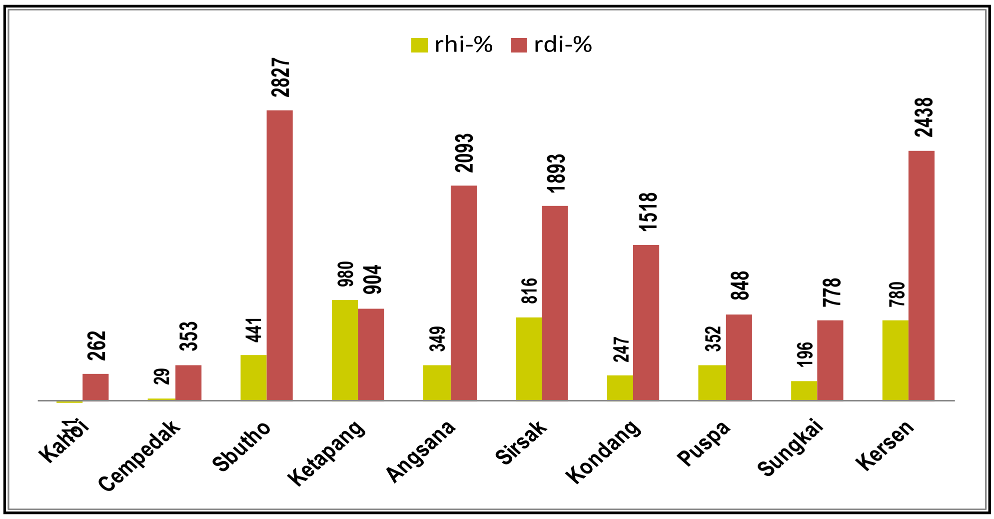


Figure-03.Relative Height (rh) and Diameter (rd) Increament of Plants 14 Months After Soil Fertiliztion

Concerning to the influence of treatments on to height increament, the biggest increament of Sengon butho, Sungkai and Kersen are at T3, Ketapang, Sirsak, Kondang and Puspa at T4, while Cempedak and Angsana at T1. Descriptive analysis of both diameter and height increaments show that most of all species - except Cempedak and Angsana, still responsive to soils fertilization. This might be due to these species needs a large amount of nutrients to grow as also they are classified as fast growing species. Bad quality of plant materials of Kahoi and Cempedak because of too long kept at nursery and being stressed growth before planting in the field. However, at the last monitoring in December 2012, there is a recovery performance on their growth indicated by several new leafs growing at the tops of their branches.

Soil Erosion Potential

Process and Mechanism

In general, soil erosion can be defined as a movement of soil mass from a site to other lower sites transported by flowing water or winds due natural process or human activities. Concerning to this process, they can be classified into geological or accelerated erosion. Normal erosion is a soil mass movement occurred at the natural condition such as eroded soil mass at slopes and/or hills. Rainfall, wind, slopes and undisturbed land surfaces are factors influencing erosion proccesses. In this stage, erosion makes a dynamic equilibrium in which the solum depth being relalively stable. This disturbed equilibrium is mostly caused by human activities tending to accelerate erosion rates. Soil erosion caused by main agent of water covers several procceses of soil detachment - dissaggregtion - dispersion - particles transportation, and eroded soils mass deposition. In the soil erosion occurrences, whether natural or accelerated, there are at least five factors causing the magnitude of soil erosion rate, that are climate, soils, topography, vegetation, and human being.

The climate element has significant influence to soil erosion is rainfall (*precipitation*), while physical soils characteristics closely related with soil erosion are texture, structure, infiltration - rate and capacity, and organic material contents. Soil texture controls water flow in the soils in form of infiltration rate, plants root penetration and water holding capacity. The occurrence of overland flow is highly depends on infiltrtation capacity and soil permeability. Landform topography has a significant role in relation with the velocity and volume of overland flow or surface runnof.

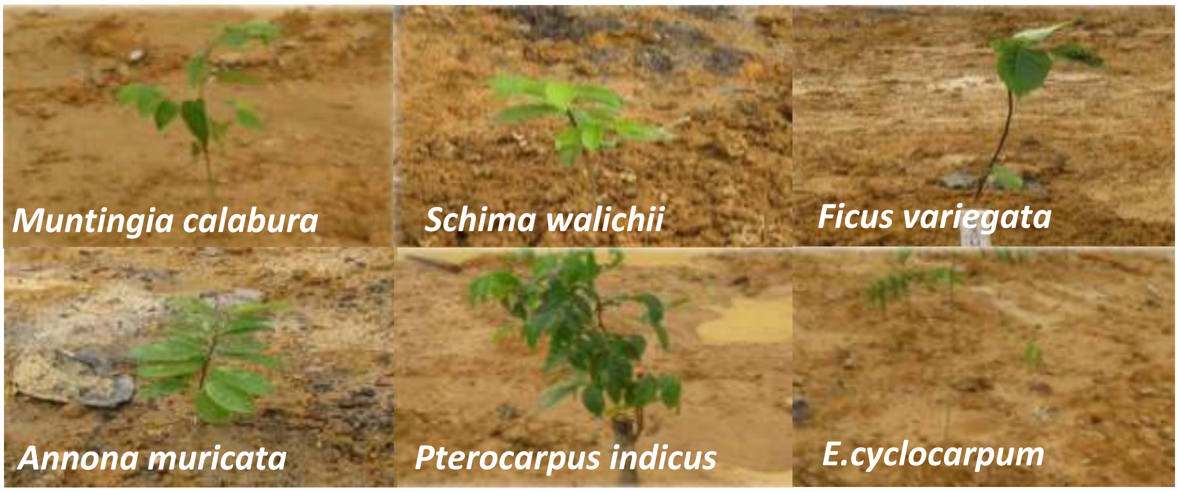


Photo-06. Condition of Mined-out Lands After Rehabilitation Works (Reclamation and Revegetation

Photo-07. Initial Growth of Land Cover and Soil Erosion 3 Months After Revegetation Works

Regarding to topography, the length and slope have an important role to soil erosion. The more steep and more length of slope, the velocity and volume of overland flow will be more bigger and finally increasing the soil erosion hazard. On the other hand, vegetation is opposite to erosive influence forces such as intercepting raindrops energy, reducing velocity and volume of overland flow and also increasing soil stability. In general, it is well known that human activities are most important factors causing a huge mass of soil erosion related with land clearing for settlements, agricultural lands, ect. Landform changes and tillage followed by soil fertilization influence the soil structures. Land clearing creates an initial condition to the occurrence of a large scale soil erosion causing the balance of soil formation and soil erosion. However, human being also plays an important role to conserve soils from erosion disturbance through various soil conservation activities such as revegetation including mined-out lands rehabilitation.

2010

Site			LT	<2T	2-4T	4-6T	>6T	LO
SMO			(VH)	(L)	(M)	(M)	(VL)	(VL)
BMO			(VH)	(L)	(L)	(VL)	(VL)	(VL)
LMO			(VH)	(VH)	(M)	(L)	(VL)	(VL)

2011

Site		LT	<2T	2-4T	4-6T	6-8T	8-10T	LO
SMO		(VH)	(L)	(M)	(M)	(VL)	(VL)	(VL)
BMO		(VH)	(L)	(L)	(VL)	(VL)	(VL)	(VL)
LMO		(VH)	(VH)	(M)	(L)	(VL)	(VL)	(VL)

2012

Site	Terbuka	<2T	2-4T	4-6T	6-8T	8-10T	>10T	LO
SMO	(VH)	(H)	(L)	(L)	(VL)	(VL)	(VL)	(VL)
BMO	(VH)	(M)	(L)	(L)	(VL)	(VL)	(VL)	(VL)
LMO	(VH)	(H)	(H)	(VL)	(VL)	(VL)	(VL)	(VL)

S, B, L - MO: Sambarata, Binungan, Lati Mining Operation, VL = Very Low <15 Ton/ha/Year, L = Low (15-60 Ton/Ha/Year), M = Modeate (60-180 Ton/Ha/Year), T = High (180-480 Ton/Ha/Year), VH = Very High (>480 Ton/Ha/Year).

Figure-04. Schematic Indication of Dynamic Soil Erosion Potential and Erosion Hazardous Index Based on Vegetation Cover Development at Mined-out Lands

Reffering to the physical soil erosion form in the field, soil erosion occurrences are generally classified as splash rosion, overland flow erosion, riil erosion, channel erosion, gully erosion, streambank erosion, and internal or sub-surface erosion. Field observation on mined-out lands revegetation is shown at **Photo-06** and **Photo-07**, as a field recording after mined-out lands reclamation (*backfilling - recontouring - reshaping - topsoils spreading*), land revegetation (land preparation - planting and 3 months development). From the field observation, it is learned that expected soil erosion reduction is land coverage at the initial stage of revegetated lands by growing various land cover crops.

As a specific refference, the research at PT Berau Coal (2010-2012) indicates that soil erosion potential related with vegetation cover development (**Figure-04**) showing that the status of Erosion Hazardous Index (EHI) at the open lands is very high (VH) during 2010-2011 years. In line with vegetation cover until 4-6 years age, the EHI declines to be very low (VL) - low (L) - moderate (M). Reaching the age of > 6 years the EHI is very low (VL). Indeed this estimation is being an indicative parameter and will vary under local specific condition such as rainfall - land slopes - rate of land coverage - vegetation maintenance - practical soil conservation. Several factors supporting the successfulness of revegetation works in line with soil erosion potential reduction, the most possible factor to be managed are slope, land prepartion and the intensity of vegetation maintenance. It also has to be well understood that lands is an synergitical aggregate factors of landform, geology, soil, hydrology, climate, flora-fauna, and its allocation usage. Therefore, land recovery is not only related with soils recovery but also the recovery of other components (micro-climate, hydrology, flora-fauna ect.).

Dynamic of Soil Erosion Potential

The phenomenon of soil erosion dynamic might be analyzed based on principles of phylosopy and functional relationship between soil erosion magnitude and important influencing factors. The development of vegetation cover is considered to be one of the most significant and important factor related with soil erosion at mined-out revegetated lands (**Photo-08**). Basically, lands disturbance e.g. mined-out lands is initially started with soils disturbances such as disrturbed soils structure and pores followed by other soils characteristics and even components forming lands. It is therefore the assessment of soil recovery should be based on pedogenesis - natural procces of soil forming and edaphologic - growth media function of biomass production points of view.

Photo-08. Growth of Plants, Land Cover and Soil Erosion 14 Months After Revegetation and Maintenance Works

Land reclamation followed by revegetation works is an effort to accelerate lands recovery and have to be supported all of needed works. Basic requirement for soils function as plants growth media are being roots system development site for supplying soils nutrition to plants. Lands reclamation works are performed by providing soil materials depth, recontouring proper landslope to guarantee proper overland flow drainage, whereas soils aeration and available soils nutrients are done in line with revegetation works. Soil erodibility is very high at open lands and decline following vegetation growth. To enhance a very low soil erosion potential depends on factors influencing it's successfulness. The most possible factors to be fully managed are slopes forming, land preparation and the intensity of vegetation maintenance works.

Topography has an important role in determining velocity and volume of overland flow. Comparing those factors, landform slope is more important than it's slope length due to flowing water velocity and it's energy to transport materials will increase following a more steep landforms. Threfore, the more slope steep and longer slope length will increase accumulated volume and the velocity of overland flow. It is found that soil erosion potential at revegetated mined-out lands decreasing from open lands - VH following the vegetation growth - H - M - L - VL consecutively. High soil erosion potential at open lands is due to lack of vegetation cover and low infiltration capacity. Direct raindrops on land surfaces causes soil particles dissaggregation - dispersion and possibly transported by overland flow along landslope into lower sites. Basically, soil erosion potential reduction might be done by intercepting direct raindrops and controlling overland flow. In the vegetative approach, planting of land cover crops might be performed while for physical - mechanical approach by constructing drainage networks. The EHI status at revegetated mined-out lands tends to decrease of which susceptibilitically indicating raindrops interception and increasing lands surfaces infiltrating exessive rainfall.

To retain and increase vegetation cover, the most possible way is by managing revegetated mined-out lands intensively. Practically, it might be performed by vegetation maintenances (*replanting dead trees*, *fertilization*, *weeds and phatogen controls, enrichment planting*) to guarantee the existence of revegetated mined-out lands. Subsequently, this also considers some facts that the status of EHI (Very Low) due to interception of direct raindrops and overland flow control by developed vegetation growth favouring a faster infiltration rate and higher infiltration capacity. Indicatively, enhancing EHI status of VL - L - M needs time at least 5 - 6 years after proper revegetation works.

Mined-out Lands Recovery

Lands Reclamation and Revegetation

Land rehabilitation (*reclamation*, *revegetation*) have to be conducted at mined-out lands to recover being a productive lands based on it's status and allocation usage. Performing such lands rehabilitation needs specific knowleges and experiences related with soil development, rehabilitation techniques, species site matching, and vegetation maintenance. Open pit system produces a mass disposal of over-burden and inter-burden which is then used to fill mined-out pits. After backfilling process, most of dumping materials is in condition of wreak or disturbed structure and pores and could be a mass of wreaks in these dumping materials. However, some time also unavoidably mixed with dirty coal and almost any organic material. This condition leads to bad drainage system and low water holding capacity, highly compacted soils followed by a high temperature. The main problem is that backfilled mined-out lands not fully ready to support plants growth and uncontrollable high overland flow followed by high soil erosion rate. In relation with planting, species site matching, planting techniques and its procedures for maintenance are also still needed to be achieved.

Land Recovery

Naturally, lands is an elements aggregate of land form, geology, soils, hydrology, climate, flora-fauna and its specific usage allocation. For this reason, lands recovery is not only concerned with soils recovery itself but also recovery of other elements. Mined-out lands disturbance is generally initiated by soils disturbance as of soil structures, pores and followed by other soil characteristics and also other elements disturbance. For this reson, lands recovery assessment have to be initiated with soils recovery viewed from pedogenesis and edaphological aspects. This means that lands recovery is not only asessed from natural forming process but also the main function as plants growth media and it's productivity.

Reclamation works followed by revegetation is an effort to accelerate land recovery process. As far as soils function works as plant growth media, it will guarantee to the availability of aeration and drainage for roots system to penetrate and providing nutrients needed by plants. In reclamation works, it is done by constructing the depth or thickness of soils materials overlay overburden layers. Increasing soil aeration can be instantly done by applying organic fertilizer, lands cover crops or other soil conditoners. Moreover, soils nutrients need for supporting plant growth can be provided by organic fertilizer application.

Lands recovery acceleration might be achieved if the minimum requirements is fulfilled. As a plant growth media, the thickness of soil materials have to be depth enough to support root system function activities and creating a proper soil drainage condition. Mined-out lands revegetation with annual plants generaly needs 50 cm thikness of materials soils and free mixed other materials. However, it is well known to be quiet difficult due to in the field has been unavoidable mixing with overburden and/or fine coals. Also, bad soil drainage is found indicated by trapped surface water at severals spots of land surfaces.

The existing degraded lands in the field can be observed from it's physical characteristics such as lack of vegetation cover, moslty eroded topsoils layer due erosion caused by surface runoff or overland flows. Facing such existing degraded lands, single or combination betwwen phyisical-mechanical and vegetative approaches migh be applied in rehabilitation works. One of selected refference, the field experience study of observation - monitoring - analysis on the dynamic of soil erosion potential at PT Berau Coal - one of a leading coal mining company (2010-2011) might be refferred in mined-out lands rehabilitation to achieve lands recovery as is shown at **Figure-05**.

Direction of Expected Development

Site	Erosion Hazardous Index (EHI)							
	OL	<2Y	2-4Y	4-6Y	6-8Y	8-10Y	>10Y	OrLand
SMO	**(VH)**	**(H)**	**(L)**	**(L)**	**(VL)**	**(VL)**	**(VL)**	**(VL)**
BMO	**(VH)**	**(M)**	**(L)**	**(L)**	**(VL)**	**(VL)**	**(VL)**	**(VL)**
LMO	**(VH)**	**(H)**	**(H)**	**(VL)**	**(VL)**	**(VL)**	**(VL)**	**(VL)**

Note:
S, B, L - MO: Sambarata, Binungan, Lati Mining Operation, VL = Very Low <15 Ton/ha/Year, L = Low (15-60 Ton/Ha/Year), M = Modetate (60-180 Ton/Ha/Year), H = High (180-480 Ton/Ha/Year), VH = Very High (>480 Ton/Ha/Year).

Figure-05.Scheme of Soil Erosion Potential Dynamic Based on Development on Lands Vegetation Cover

As mentioned before, magnitude of soil erosion potential is influenced by main factors of rainfall erosivity, soil erodibility, length and slope, vegetation cover, and the application of soil and water conservation practices. The dynamics of lands vegetation cover is a significant factor in relation with the soil erosion dynamic at mined-out lands. In line with it's vegetation cover development in 4-6 years, KBE status decreases from VH to VL - L - M. When the vegetation reaches > 6 years in age, KBE decreases into VL. These KBE decrease indicate that management of mined-out lands related with it's expected recovery have to be intensively performed at least at the first 5 years after revegetation works. Specifically, lands recovery efforts have to pay much attention on slope construction and lands preparation at reclamation step, and the intensity of plants management covering species selection, planting techniques and plants maintenance.

The initial works of lands rehabilitation based on physical-mechanical approahes combined with vegetative approach are to control surface runoff/overland flows, especially at lands with hard topography. It is aimed in order the force of surface runoff can be properly controlled and the transportability of eroded soil particles being significantly decrease. This can be done by cutting the slope length to reduce surface runoff velocity and as far as possible directing into designed places to undisturb mined-out lands. The surface runoff control actualy depends on it's physical-mechanical function. If surface runoff can be successfully controlled, it will make possible condcuting lands preparation followed by planting at available planting areas of mined-out lands.

Vegetation plants is expected to grow and developing crown trees to intercep direct rainfall force and therefore reducing it's rainfall drops energy, covering lands surfaces and increasing the possibility of rainfall water reached lands surface to infiltrate into the soils, anf finally surface runoff savely flowing over the lands. One of the important thing is that nutrients lost can be avoided and the soils nutrients being retained. If vegetation plants grow well will promote nutrients cycle and leading to recovery at mined-out lands by accumulating organic materials forming topsoils. For the next step if the developed plants still not fully match with in function as expected before, it is possible to change or enrich with other expected plants species. The principles of mined-out lands mentioned above should be performed step by step consecutivelly and needs enough time to succeed. Each step of mined-out lands rehabilitation will be important and being foundation for the next effort step of it's land rehabilitation.

Conclusions

01. As much as 3000 individual plants studied, the survived plants including replanting is 2.788 individu (93%) with the lowest Cempedak (84%) and Sungkai (86%). Best physical performance in the field are Kersen, Ketapang and Sirsak while the worse are Kahoi, Cempedak and Angsana;
02. Soils is found to be very compact with average BD 1,68 g/cc (1,51-1,80 g/cc). Most of soils volume (64%) is mineral and only 36,36% filled with air and water. There is no difference in chemical soils fertility status between upper and lower soil layers and both layers are acid with very low N, P, K contents, moderate CEC and very high base saturation. Soils acidity increases by adding dolomite 0,5 kg/plant and changing status from acid into close to neutral;
03. The application of NPK (16:16:16) with 150 g/plant dosage does not change N status in the soils while 50 g/plant dosage changing P and K status from very low to very high;
04. Increasing nutrients lost at open mined-out lands is due to high volatyle N and it's mobility while for P and K changing can be compensated by organic fertilizer application;
05. Organic fertilizer application 20 kg/plant is due to reduce soils compaction and at the same time increasing soils pores and CEC and water contents. Field observation indicates that organic fertilizer causing a large influence upon plants growth due to a better physical soils characteristics and therefore root system functioning properly;
06. All of soil fertilization treatments by applying NPK (16:16:16) increase P and contetns but not for N in soils. The dosage of 100 g NPK (16:16:16) per plant (T3) increases a maximum plant height and diameter of Sengon butho, Sungkai and Kersen, and for Ketapang and Puspa diameter only. Dosage of 150 g NPK (16:16:16) per plant (T4) similarly increases a maximum plant height and diameter of Sirsak and Kondang, while for Kahoi (diameter) and for Ketapang and Puspa (height). Until 14 months plant age, all plants are still responsive to fertilization application except Cempedak and Angsana;
07. Soil erosion potential at open mined-out lands is very high due to lack of vegetation cover, low infiltration capacity and a high overland flow/surface runoff. Subsequently, at revegetated mined-out lands tends to decline into very low - moderate range, indicating there is an interception raindrops energy and increasing infiltration capacity;
08. To achieve a very low soil erosion potential at revegetated mined-out lands needs an effective time at least in about 5-6 years. The most important factors highly possible to be consistently managed are reclamation works (recountouring, reshaping) and revegetation works (plants maintenance);
09. The phenomenon of soil erosion potential dynamic is depend on influencing factors upon soil erosion occurences that are rainfall erosivity, soil erodibility, landform slope and lenths, vegetation cover, practical soil and water conservation. Development of vegetation growth cover is the most significant factor related with the soil erosion dynamic at revegetated mined-out lands.

Recommendation

01. Additional organic materials application should be continued in the proper amount to reduce soils compactness, increasing soils pores and water contents;
02. Considering a very low contents of N, P, K nutrients and it's increasing need, the dosage of N fertilizer should be added in amount to increase N contents as fast as possible. Meanwhile, the recommended dosage of NPK (16:16:16) for Sengon butho Sungkai, Kersen, Ketapang, and Puspa is 100 g/plant, whereas for Sirsak, Kondang and Kahoi 150 g/plant, and for Angsana and Cempedak is 50 g/plant;
03. Considering that reducing soils erosion rate is performed by intercepting raindrops and controlling overland flow, the practical alternatives based on vegetative approch is by planting land cover crops - fast growing trees - annual plants, while for physical and mechanical based approach is by preparing drainage networks with proper capacities;
04. To realize and retain the intensity of land covers for reducing soils erodibilty requiers an intensive maintenance of revegetated mined-out lands by performing vegetation growth and development management. It will be more effective in line with prior to proper slope and length preparation in mined-out lands reclamation works.

Referrences

Arsyad, S., 2006. Konservasi Tanah dan Air. IPB Press. Bogor

Bradshaw, A.D. 2002. Introduction and Philosophy. Perrow and A.J. Davy (eds). Handbook of Ecological Restoration. Vol 1: Principles of Restoration. Cambridge University Press, The Edinburgh Building, Cambridge CB2 2RU, UK.

Buckman, H.O. dan N.C. Brady. 1982. Ilmu Tanah. Alih Bahasa: Soegiman. Bharata Karya Aksara, Jakarta. 788 h.

Foth. H.D. 1998. Dasar-dasar Ilmu Tanah. Alih Bahasa: Purbayanti E.D; D.W. Lukitawati dan R. Trimulatsih. Edisi Ketujuh. Gajah Mada University Press, Yogyakarta. 295 h.

Hardjowigeno, S.1987. Ilmu Tanah. Edisi Revisi. PT. Mediyatama Sarana Perkasa, Jakarta. 233 h.

Hartati, W., Sudarmadji, T., Syafrudin, M., 2010. Pemantauan Dinamika Mikroklimat dan Tingkat Kesuburan Tanah serta Potensi Erosi pada Lahan Revegetasi Pasca Tambang PT Berau Coal.

Hartati, W., Sudarmadji, T., Syafrudin, M., 2011. Pemantauan Dinamika Mikroklimat dan Tingkat Kesuburan Tanah serta Potensi Erosi pada Lahan Revegetasi Pasca Tambang PT Berau Coal.

Hartati, W., Sudarmadji, T., Syafrudin, M., 2012. Pemantauan Dinamika Mikroklimat dan Tingkat Kesuburan Tanah serta Potensi Erosi pada Lahan Revegetasi Pasca Tambang PT Berau Coal.

Peraturan Menteri Kehutanan Nomor P.70/Menhut-II/2008 tanggal 11 Desember 2008 tentang Pedoman Teknis Rehabilitasi Hutan dan Lahan, disempurnakan dengan Permenhut No.26/Menhut-II/2010 Tanggal 1 Juni 2010.

Peraturan Menteri Kehutanan Republik Indonesia Nomor: P.12/Menhut-II/ 2011 tentang Pedoman Penyelenggaraan Rehabilitasi Hutan dan Lahan Tahun 2011.

Peraturan Pemerintah Nomor 76 Tahun 2008 tentang Rehabilitasi dan Reklamasi Hutan.

PT Berau Coal, 2009. Rencana Penutupan Tambang tahun 2025 PT Berau Coal.

Rahmawaty, 2002. Restorasi Lahan Bekas Tambang berdasarkan Kaidah Ekologi, Fakultas Pertanian, Universitas Sumatera Utara, Medan.

Ruhiyat, D. 1999. Potensi Tanah di Kalimantan Timur, Karakteristik dan Strategi Pendaya-gunaannya. Fakultas Kehutanan Universitas Mulawarman, Samarinda. 46 h.

Tan, K.H. 1998. Dasar-dasar Kimia Tanah. Alih Bahasa: Goenadi, D.H. Gajah Mada Univ. Press, Yogyakarta. 295 h.