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Research Article

Plant species from coal mine overburden dumping site in Satui, South Kalimantan, Indonesia

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Abstract

Coal mine overburden (OB) materials were nutrient-poor, loosely adhered particles of shale, stones, boulders, and cobbles, also contained elevated concentration of trace metals. This condition cause OB substrate did not support plants growth. However, there were certain species that able to grow on overburden dumping site. This investigation sought to identify plants species that presence on coal mine overburden. The research was conducted on opencast coal mine OB dumping site in Satui, South Kalimantan. Vegetation sampling was carried out on six different ages of coal mine OB dumps (7, 10, 11, 42, 59 and 64 month) using line transect. Species identification used information from local people, AMDAL report of PT Arutmin Indonesia-Satui mine project, and website. There were 123 plant species, consisted of 79 herbs (Cyperaceae, Poaceae and Asteraceae), 10 lianes, bryophyte, 9 ferns, 10 shrubs, and 14 trees. A number of Poaceae, i.e., *Paspalum conjugatum*, *Paspalum dilatatum*, and *Echinochloa colona* generally present among the stones, boulders, and cobbles. While Cyperaceae such as *Fimbristylis miliaceae*, *Cyperus javanicus*, *Rhyncospora corymbosa* and *Scleria sumatrensis* most often found in and around the basin/pond with its smooth and humid substrate characteristics. Certain species of shrubs and trees have been present on the 7 month OB dumping site. They were *Chromolaena odorata*, *Clibadium surinamense*, *Melastoma malabathricum*, *Trema micrantha*, and *Solanum torvum* (Shrubs), *Ochroma pyramidale* and *Homalanthus populifolius* (trees). This plant species could be used for accelerating primary succession purpose on coal mine overburden dumping site. Nevertheless, species selection was needed to avoid planting invasive species.

Keywords: *accelerating, mining, overburden, plants, succession*

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Introduction

Ninety five percent coal mine in Indonesia using opencast mining method (Gautama 2007; Setianingprang and Riawan, 2008). The chief environmental impacts of its practice are changes in soil stratification, reduced biotic diversity, and alteration of structure and functioning of ecosystems; these changes ultimately influence water and nutrient dynamics, and trophic interactions (Matson et al., 1997; Almas et al., 2004; Ghose, 2004). Furthermore, loss of soil during stripping and stockpiling causes not all mined areas will be recovered with soil during revegetation (BPK, 2008). This area is known as overburden (OB). Coal mine overburden is stone, located above (referred to as roof rock) or between (interburden) or below (floor rock) the coal (Novianti, 2013). OB materials are nutrient-poor, loosely adhered particles of shale, stones, boulders, cobbles, and so forth (Gogoiet al., 2007; Novianti, 2013). Mine OB materials also contain elevated concentrations of trace metals (Dobson et al., 1997; Novianti, 2013). This character of overburden is the reason why fast growing and invasive species, such as *Acacia mangium*, is planted on previously mined coal areas. Therefore, reclamation approach to improve post-coal mining land has not yet successful because there is no implication of returning to an original state and restore biodiversity but rather to a useful one.

Overburden condition is identical to the primary succession i.e. vegetation development on newly formed or exposed substrate, proceeds on raw material rather than a developed or modified soil, and is usually characterized by low fertility, no biological legacy (no previous vegetation, no seed bank, no organic matter derived from prior vegetation) (Glenn-Lewin et al., 1992). Hence, ecologycal succession in a mine OB is a lengthy process. A minimum period of ecologycal succession is 50 years to a century to establish advanced specific plant species in denuded, mine OB-filled land; but this long time scales due to specific problems can be overcome by artificial interventions, that once identified, which are most successful if they use or mimic natural process (Dobson et al., 1997).

Local vegetation is one of the keys of this process. This investigation sought to identify plant species that present on coal mine OB dump. This study will be helpful in giving references of coal mine OB plant species in order to accelerate ecological restoration on coal OB dumping site. This research was conducted in Satui, South Kalimantan. Kalimantan or also known as Borneo is host to a vast area of the country`s remaining tropical rainforests where various endemic flora and fauna can be found. Rainforests in the Heart of Borneo also have a crucial function as the lungs of the world because they produce oxygen needed to help overcome the impact of climate change. On the other hand, it contains nearly 60 percent of Indonesia's coal reserves where over exploitation occur. Ecological restoration approach is thus critical to be carried out in Kalimantan to restore its biodiversity and ecosystem function.

Materials and Methods

Description of study area

The study was conducted at the mine site of PT. Arutmin Indonesia (AI), Satui mine project in South Kalimantan, Indonesia. Mining operational and office area are located at a distance of ± 165 km Southeast of Banjarmasin.

Characteristics and determination of overburden age as study area

Vegetation sampling area was carried out on out-pit dump (overburden that dumped at dedicated disposal site outside the mine pit), and without leveled on its surface (free dump). Determination of OB dumping site is based on the following conditions: (1) no disposal process (final dump), (2) the age of mine OB is known, (3) the origin depth of OB is identified, and (4) geology formation of OB is identified. According to that requirement, there are six overburden used as vegetation sampling location (Table 1).

Table 1. Characteristics of overburden dumping site as study area

No.	Age of mine OB (month)	High of OB dump (m)	Width of OB Dump (ha)	Origin depth (m asl)
1	7	38.18	2.68	30 s/d -80
2	10	20.07	2.06	30 s/d -80
3	11	16.18	3.66	30 s/d -80
4	42	19.90	7.09	30 s/d -80
5	59	24.11	2.14	30 s/d -80
6	64	29.85	11.87	30 s/d -80

determination of coal mine OB is based of the following formula:

$T = T_2 - T_1$

Annotation:
T = age of mine OB (month)
T_2 = starting time of sampling vegetation (month and year)
T_1 = time of final OB dump (month and year)

The origin depth and geological formation of coal mine OB in each pile was obtained using geological data belong to PT. Arutmin, Satui mine project.

Vegetation sampling and species identification

Vegetation sampling was conducted using line transect. The lenght of line transect following the lenght of OB dump area that able to be reached. In order to represent plant communities on coal mine dumping site, the distance between transect are made of 5 m while total line transect following the width of dump area that can be accomplished (Figure 1).

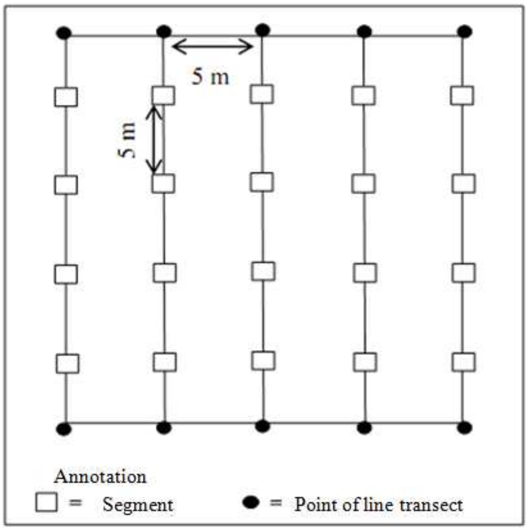

Figure 1. Ilustration of line transect in an OB dump area

Segment sign is made in every five meter of line transect to facilitate the process of sampling (Figure 2). Each plant that exposed to the transect line is recorded, documented (using camera) and coded for further species identification through local people, EIA report of PT. AI Satui Mine Project, and website bellow:

1. http://www.nationalherbarium.nl/MacMalBorneo/indonesian/index.htm
2. http://www.indonesianchm.or.id
3. http://www.biotrop.org/database.php?act=dbias&kategori=&paper=1
4. http://www.natureloveyou.sg/plants-D.html
5. http://www.iewf.org/weedid/All_common_name.htm
6. http://www.rimbundahan.org/environment/plant_lists/dipterocarpaceae/index.htm
7. http://www.dld.go.th/nutrition/ANIMAL_NUTRITION_DIVISION_files/Native_grass.htm
8. http://app.ctu.edu.vn/forum/viewtopic.php?p=34293&sid=a6744de8ccd359178366065b38a06346
9. http://app.ctu.edu.vn/forum/viewtopic.php?p=78508&sid=70b76c420bff5faa564bd35
10. http://www.natres.psu.ac.th/Departement/PlantScience/weed/weedinplantation.htm
11. http://www.plantamor.com

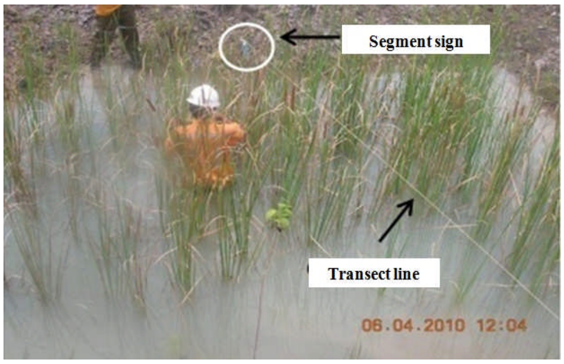

Figure 2. Segment on transect line

Results and Discussion

Typology of coal mine overburden

Stockpiles of overburden was like a hill. The top of it consists of flat and uneven part (Figure 3). The uneven section due to a number of OB mounds so that its surface becomes undulating. Therefore, it can be devided into three parts i.e., peak, slope and valley (Figure 4). The valley formed by confluence of several OB mounds will form a basin that will be filled water when rain comes so that it resembles a pond. The size and depth of basin are varies (Figure 5). This stagnant water accelerates the destruction of boulder (>256 mm), cobble (64-256 mm), and gravel (2-4 mm) develop into clay (1/256 mm). In contrast to substrate that is not inundated by water still in the form of boulder, cobble, and gravel for a longer period of time. Eventually, the differences of particel size and moisture played a role in determining the types of plants which present on coal mine OB dump. The compositions of overburden substrate at six study sites are boulder, pebble, cobble and gravel of clay stone. According to PT. Arutmin Indonesia (2009), Tanjung Formation in Satui Mine derived from Eocene aged (± 50 million years).

Plants species on coal mine overburden dumping site

Based on species identification on six overburden dumps, there are 123 plants species consisting of 79 herbs (grass, sedge, and herbaceous flowering), 10 lianas, lichen, 9 ferns, 10 shrubs, and 14 trees that able to grow on OB substrate (Table 2).

Figure 3. Overburden stockpile was like a hill (A-B). The top of it comprises of flat (C) and uneven (D)

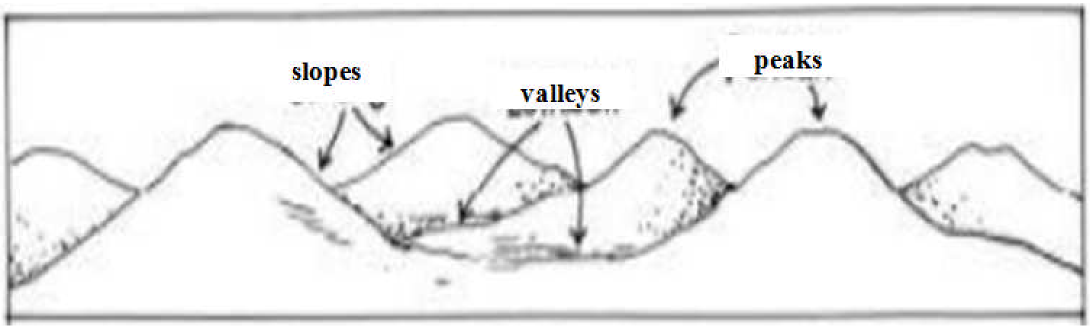

Figure 4. Illustration of undulating surface on coal mine OB dump (Source: Hairiah et al., 2000)

Figure 5. Some basins are formed by the confluence of OB mounds

Table 2. Plants species and life form on six overburden dumps

No.	Name	Family	Life span	Class	Age of overburden (month)					
					7	**10**	**11**	**42**	**59**	**64**
	Herbs									
1	*Ageratum conyzoides* Linn.	Asteraceae	Annual	Magnoliopsida				v	v	v
2	*Andropogon aciculatus* Retz.	Poaceae	Annual	Liliopsida						v
3	*Andropogon chinensis* (Ness) Merr.	Poaceae	Annual	Liliopsida						v
4	*Blyxa japonica* (Mix.) Maxim.	Hydrocharitaceae	Annual	Liliopsida			v			
5	*Celosia argentea* Linn.	Amaranthaceae	Annual	Magnoliopsida		v			v	v
6	*Cyperus babakans* Steud.	Cyperaceae	Annual	Liliopsida			v		v	
7	*Cyperus brevifolius* (Rottb.) Hassk	Cyperaceae	Annual	Liliopsida						v
8	*Cyperus compactus* Retz.	Cyperaceae	Annual	Liliopsida			v	v	v	v
9	*Cyperus compressus* Linn.	Cyperaceae	Annual	Liliopsida					v	v
10	*Cyperus difformis* Linn.	Cyperaceae	Annual	Liliopsida			v		v	
11	*Cyperus entrerianus* Boeckl.	Cyperaceae	Annual	Liliopsida					v	v
12	*Cyperus halpan* Linn.	Cyperaceae	Annual	Liliopsida		v				v
13	*Cyperus iria* Linn.	Cyperaceae	Annual	Liliopsida			v		v	
14	*Cyperus javanicus* Houtt	Cyperaceae	Annual	Liliopsida	v	v	v		v	v
15	*Cyperus kyllinga* Endl.	Cyperaceae	Annual	Liliopsida	v		v	v		v
16	*Cyperus polystachyos* Rottb.	Cyperaceae	Annual	Liliopsida					v	v
17	*Cyperus pulcherrimus* Will. Ex. Kunth.	Cyperaceae	Annual	Liliopsida			v			v
18	*Cyperus pygmaeus* Rottb.	Cyperaceae	Annual	Liliopsida						v
19	*Cyperus* sp.1	Cyperaceae	Annual	Liliopsida					v	
20	*Cyperus* sp.2	Cyperaceae	Annual	Liliopsida					v	
21	*Cyperus* sp.3	Cyperaceae	Annual	Liliopsida					v	v
22	*Cyperus* sp.4	Cyperaceae	Annual	Liliopsida			v		v	
23	*Cyperus* sp.5	Cyperaceae	Annual	Liliopsida			v			
24	*Cyperus* sp.6	Cyperaceae	Annual	Liliopsida			v			
25	*Axonopus compressus*	Poaceae	Annual	Liliopsida		v				
26	*Cyperus sulcinux* C. B. Clarke.	Cyperaceae	Annual	Liliopsida	v	v	v	v	v	v
27	*Demodium heterophyllum* (Willd.) DC.	Fabaceae	Annual	Liliopsida						v
28	*Echinochloa colona* (Linn.) Link.	Poaceae	Annual	Liliopsida	v	v	v	v	v	v
29	*Eclipta prostrata* Linn.	Asteraceae	Annual	Magnoliopsida					v	
30	*Eleusine indica* (L.) Gaertn.	Poaceae	Annual	Liliopsida	v	v	v		v	v
31	*Emilia sonchifolia* (Lin.) DC.	Asteraceae	Annual	Magnoliopsida			v	v	v	v
32	*Eragrostis japonica* (Thunb.) Trin.	Poaceae	Annual	Liliopsida		v	v	v	v	v

No.	Name	Family	Life span	Class	Age of overburden (month)					
					7	10	11	42	59	64
33	*Eragrostis leptostachya* (R. Br.) Steud.	Poaceae	Annual	Liliopsida		v				
34	*Eragrostis tenella* (Linn.) P Beauv.	Poaceae	Annual	Liliopsida	v		v	v	v	v
35	*Eragrostis unioloides* (Retz.) Nees ex Steud.	Poaceae	Annual	Liliopsida						
36	*Erechtites valerianifolia* (Wollf) DC.	Asteraceae	Annual	Magnoliopsida			v		v	v
37	*Eulophia graminae* Lindl.	Orchidaceae	Annual	Liliopsida						v
38	*Fimbristylis dichotoma* (Linn.) Vahl.	Cyperaceae	Annual	Liliopsida	v	v	v	v	v	v
39	*Fimbristylis miliaceae* (Linn.) Vahl.	Cyperaceae	Annual	Liliopsida	v	v	v	v	v	v
40	*Fimbristylis schoenoides* (Retz.) Vahl.	Cyperaceae	Annual	Liliopsida					v	v
41	*Fimbristylis* sp.1	Cyperaceae	Annual	Liliopsida						v
42	*Fimbristylis* sp.2	Cyperaceae	Annual	Liliopsida						v
43	*Hyptis capitata* Jacq.	Lamiaceae	Annual	Magnoliopsida					v	v
44	*Ipomoea aquatica* Forsk.	Convolvulaceae	Annual	Magnoliopsida			v			
45	*Lindernia crustacea* (Linn.) F.Muell.	Scrophulariaceae	Annual	Magnoliopsida			v		v	
46	*Melochia corchorifolia* Linn.	Sterculiaceae	Annual	Magnoliopsida	v				v	v
47	*Mitracarpus hirtus* (Linn.) DC	Rubiaceae	Annual	Magnoliopsida			v			
48	*Polygala paniculata* Linn.	Polygalaceae	Annual	Magnoliopsida						v
49	*Porophyllum ruderale* (Jacq.) Cass.	Asteraceae	Annual	Magnoliopsida		v	v	v	v	v
50	*Scleria bancana* Miq.	Cyperaceae	Annual	Liliopsida						v
51	*Scleria sumatrensis* Retz.	Cyperaceae	Annual	Liliopsida	v	v	v	v	v	v
52	*Vernonia cinerea* (L.) Less.	Asteraceae	Annual	Magnoliopsida			v		v	v
53	*Ottochloa nodosa* Kunth.	Poaceae	Annual	Liliopsida						v
54	*Alternanthera pungens* Kunth.	Amaranthaceae	Perennial	Magnoliopsida	v		v			
55	*Alternanther asessilis* Linn.	Amaranthaceae	Perennial	Magnoliopsida	v	v	v		v	v
56	*Centotheca lappacea* (Linn.) Desv.	Poaceae	Perennial	Liliopsida			v			v
57	*Chloris barbata* Swartz.	Poaceae	Perennial	Liliopsida					v	
58	*Cynodon dactylon* (Linn.) Pers.	Poaceae	Perennial	Liliopsida	v	v			v	v
59	*Dactyloctenium aegyptium* (Linn.) Willd.	Poaceae	Perennial	Liliopsida					v	
60	*Digitaria ciliaris* (Retz.) Koeler	Poaceae	Perennial	Liliopsida			v			v
61	*Elaphoglossum blumeanum* (Fée) J. Sm.	Elaphoglossaceae	Perennial	Polypodiopsid					v	v
62	*Elocharis dulcis* (Burm. f.) Trin. ex. Henschel.	Cyperaceae	Perennial	Liliopsida			v	v		v
63	*Erigeron sumatrensis* Retz.	Asteraceae	Perennial	Magnoliopsida					v	v
64	*Imperata cylindrica* (L.) Raeuschel	Poaceae	Perennial	Liliopsida	v	v	v	v	v	
65	*Leersia hexandra* Swartz	Poaceae	Perennial	Liliopsida	v	v		v	v	v
66	Vitaceae	Vitaceae	Perennial	Magnoliopsida					v	v

No.	**Name**	**Family**	**Life span**	**Class**	**Age of overburden (month)**					
					7	**10**	**11**	**42**	**59**	**64**
67	*Ludwigia hyssopifolia* (G. Don) Exell.	Onagraceae	Perennial	Magnoliopsida			v	v	v	v
68	*Neyraudia reynaudiana* (Kunth) Keng ex Hitchc	Poaceae	Perennial	Liliopsida	v		v	v	v	v
69	*Panicum repens* Linn.	Poaceae	Perennial	Liliopsida				v		
70	*Paspalum conjugatum* Berg.	Poaceae	Perennial	Liliopsida	v	v	v	v	v	v
71	*Paspalum dilatatum* Poir.	Poaceae	Perennial	Liliopsida	v	v	v	v	v	v
72	*Paspalum scrobiculatum* Linn.	Poaceae	Perennial	Liliopsida	v	v	v	v	v	v
73	*Phyllanthus urinaria* Linn.	Euphorbiaceae	Perennial	Magnoliosida					v	v
74	*Rhyncospora corymbosa* (Linn.) Britton	Cyperaceae	Perennial	Liliopsida	v	v	v	v	v	v
75	*Saccharum spontaneum* Linn.	Poaceae	Perennial	Liliopsida					v	v
76	*Sacciolepis indica* (Linn.) Chase	Poaceae	Perennial	Liliopsida	v	v				v
77	*Sacciolepis strata* (Linn.) Nash	Poaceae	Perennial	Liliopsida		v				
78	*Scirpus mucronatus* (Linn.) Palla	Cyperaceae	Perennial	Liliopsida		v	v	v		
79	*Typha angustifolia* Linn.	Typhaceae	Perennial	Liliopsida	v	v	v	v	v	v
	Liana									
80	*Citrullus lanatus* (Thunb.)	Cucurbitaceae	Annual	Magnoliosida				v		
81	*Mimosa pudica* Linn.	Fabaceae	Annual	Magnoliosida			v	v	v	v
82	*Araujia hortorum* E. Fourn	Asclepiadaceae	Perennial	Magnoliosida			v		v	v
83	*Benincasa hispida* (Thunb.) Cogn.	Cucurbitaceae	Perennial	Magnoliosida			v			
84	*Centrosema molle* Benth.	Fabaceae	Perennial	Magnoliosida					v	v
85	*Centrosema pubescens* Benth.	Fabaceae	Perennial	Magnoliosida					v	v
86	*Hodgsonia heteroclita* (Roxb.) Hook f. & Thomson	Cucurbitaceae	Perennial	Magnoliosida		v				
87	*Mikania micrantha* Kunth.	Asteraceae	Perennial	Magnoliosida			v			v
88	*Passiflora foetida* Linn.	Passifloraceae	Perennial	Magnoliosida	v		v	v	v	v
89	*Wedelia trilobata* (Linn.) Hitchc.	Asteraceae	Perennial	Magnoliosida			v		v	
	Bryophyte									
90	Bryophyta		Annual		v		v	v	v	V
	Ferns									
91	Fern sp.1		Annual						v	
92	*Christella dentata* (Forsk.) Browney & Jermy	Thelypteridaceae	Perennial	Filicopsida				v		
93	*Lycopodium cernuum* Linn.	Lycopsida	Annual	Lycopodiopsida					v	
94	*Lygodium microphyllum* (Cav.) R Br.	Lygodiaceae	Annual	Filicopsida			v	v		
95	*Nephrolepis* sp.	Nephrolepidaceae	Annual	Filicopsida				v		
96	*Blechnum orientale* Linn.	Blechnaceae	Perennial	Pterdidopsida		v				v
97	*Pityrogramma calomelanos* (Linn.) Link	Polypodiaceae	Perennial	Pterdidopsida	v		v	v	v	v

No.	Name	Family	Life span	Class	Age of overburden (month)					
					7	10	11	42	59	64
98	*Pteridium esculentum* (G. Forst.) Cockayne	Dennstaedtiaceae	Perennial	Pteridopsida				v		
99	*Pteris vittata* Linn.	Pteridaceae	Perennial	Filicopsida			v	v	v	v
	Shrubs									
100	*Blumea balsaminifera* (Linn.) DC.	Asteraceae	Perennial	Magnoliosida	v				v	v
101	*Chromolaena odorata* (Linn.) King & Robinson	Asteraceae	Perennial	Magnoliosida	v	v	v	v	v	v
102	*Clibadium surinamense* Linn.	Asteraceae	Perennial	Magnoliosida	v	v	v	v	v	v
103	*Lantana camara* Linn.	Verbenaceae	Perennial	Magnoliosida						v
104	*Leea indica* (Burm.f.) Merr.	Vitaceae	Perennial	Magnoliosida			v			v
105	*Melastoma malabathricum* Linn.	Melastomaceae	Perennial	Magnoliosida	v	v	v		v	
106	*Piper aduncum* Linn.	Piperaceae	Perennial	Magnoliosida						v
107	*Solanum torvum* Swartz.	Solanaceae	Perennial	Magnoliosida	v	v	v		v	v
108	*Trema micrantha* (L.) Blume	Ulmaceae	Perennial	Magnoliosida	v	v	v	v	v	v
109	*Trema orientalis* (L.) Blume	Ulmaceae	Perennial	Magnoliosida	v	v	v	v	v	v
	Trees									
110	*Morinda citrifolia* Linn.	Rubiaceae	Perennial	Magnoliosida						v
111	*Ochroma pyramidale* (Cav. Ex Lam.) Urb.	Bombacacea	Perennial	Magnoliosida	v					
112	*Acacia mangium* Wild.	Fabaceae	Perennial	Magnoliosida			v		v	v
113	*Anthocephalus macrophyllus* Havil.	Rubiaceae	Perennial	Magnoliosida					v	
114	*Homalanthus populifolius* Graham	Euphorbiaceae	Perennial	Magnoliosida	v		v	v		v
115	*Macaranga gigantea* (Reichb.f.& Zoll.) Műll.Arg.	Euphorbiaceae	Perennial	Magnoliosida		v				
116	*Macaranga tanarius* (L.) Muell.Arg.	Euphorbiaceae	Perennial	Magnoliosida					v	v
117	*Mollatus paniculatus* (Lam.) Mull.Arg.	Euphorbiaceae	Perennial	Magnoliosida			v			v
118	*Palaquium oblongifolium* (Burck) Burck	Sapotaceae	Perennial	Magnoliosida						v
119	Tree sp. 1		Perennial	Magnoliosida			v			
120	Tree sp. 2		Perennial	Magnoliosida			v			
121	Tree sp. 3		Perennial	Magnoliosida					v	
122	Tree sp. 4		Perennial	Magnoliosida					v	
123	*Psidium guineense* Swartz	Myrtaceae	Perennial	Magnoliosida						v

Particular species of Poaceae, i.e., *Paspalum conjugatum*, *Paspalum dilatatum*, and *Echinochloa colona* are mostly present among the boulders, cobble and gravel. While, Cyperacea such as *Fimbristylis miliaceae*, *Cyperus javanicus*, *Rhyncospora corymbosa*, and *Scleria sumatrens* is generally found in and around the bassin that contain refined substrate and moist condition (Figure 6). It indicates that Cyperaceae needs better substrate physically (grain size) and chemically (humidity) than Poaceae. According to Del Moral and Bliss (1993), undulating area gives higher soil humidity because of the present of stagnant water and keep refined particle compare to the flat area.

Figure 6. Substrate of Cyperaceae (A-C) and Poaceae (D-F)

Figure 7. Seedling of *Ochroma pyramidale* (top) and *Homalanthus populifolius* (bottom) at the age of seven months coal mine OB dump

According to Aththorick (2005), cover vegetation commonly are Poaceae, Cyperaceae, and Asteraceae. They are grass, sedge, herbs, and small shrubs. Some of them are annual, binual and perennial with life form are clump, solitary, erect, liana or climbing. Odum (1993) states that early stage development of a community is characterized by low organic matter while inorganic nutrients are extrabiotic, biochemical diversity is low and space heterogeneity is high. Vegetation that able to utilize that kind of community structure is species with reproduction strategy "ruderal selection" and production is based on quantity. This vegetation is herbs and mostly is grass. Some of certain shrubs and trees have been present at the age of seven months on coal mine OB dump, shows that substrate has been available for vascular plants. They are *Chromolaena odorata*, *Clibadium surinamense*, *Melastoma malabathricum*, *Trema micrantha*, *Solanum torvum* (shrubs), *Ochroma pyramidale* and *Homalanthus populifolius* (trees) (Figure 7). This result indicates that revegetation acceleration can be done on coal mine OB dump by applying plant species above which have been proven able to grow on substrate OB condition. However, species selection is needed to avoid planting of invasive species such as *Acacia mangium* and *Centrosema pubenscens*.

Conclusions

Although physical, chemical and biological of coal mine OB substrates do not support the growth of many plants, but there are particular species present on OB substrate. Cyperaceae (such as *Fimbristylis miliaceae*, *Cyperus compactus*, *Scleria sumatrensis*, *Rhyncospora corymbosa*) often found in and around ponds, while Poaceae (*Paspalum conjugatum* and *Echinocloa colona*) and liana (*Passiflora foetida*, *Hodgsonia heteroclita* and *Benincasa hispida*) are generally present among boulders, rubble, gravel and pebbles. Accelerating succession on coal mine OB dumps can be implemented by planting the species above (Table 2), but selection is needed to avoid invasive species.

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