
Research Article**The Checklist of Plants Occurring at the Abandoned Mamut Copper Mine, Sabah, Malaysia**Kartini Saibeh^{1*}, John Sugau², Rimi Repin³¹*Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia*²*Forest Research Centre, Sabah Forestry Centre, PO BOX 1407, Sepilok, 90715 Sandakan, Sabah, Malaysia*³*Sabah Parks, PO BOX 10626, 88806 Kota Kinabalu, Sabah, Malaysia*

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Abstract

The abandoned Mamut Copper Mine (MCM) is located at the southeastern slope of Mount Kinabalu. It lies between elevations of 1,300 to 1,600 metres above sea level. General collection of plants was carried out on the five main waste rocks dumping sites: Mamut Valley Dump, Lohan Dump, Nasapang Dump, North Dump and West Dump. The enumeration recognizes 204 species represented by 73 different families and 152 different genera. Of these, 59 are tree species, 55 shrub species, 64 herbaceous species (including ferns), 23 graminoid species, and two moss species. This study has identified 25 plant species that are frequently found at all of the waste dumpsites around the abandoned MCM. This checklist can be used for a rehabilitation programme of mine wastes.

Keywords: Colonization, mine rehabilitation, waste dump**Introduction**

Mamut in Ranau is an ex-copper production site and was the first opencast mine in Malaysia. The former Mamut Copper Mine (MCM) was in operation for 24 years from 1975 to 1999. It produced copper concentrate that also contained significant amounts of gold and silver. The mining lease covers an area of 1942 hectares of rugged montane terrain on the southeastern slopes of Mount Kinabalu. It is located between the elevations of 1,300-1,600 metres above sea level. The overburden materials and waste rocks were dumped at five main dumpsites called Mamut Valley Dump, Lohan Dump, Nasapang Dump, North Dump and West Dump. The open pit, process-plant site and waste rock dumping areas occupy an area of over 200 hectares (Figure 1). The annual precipitation at the mine area varies little from year to year. There is a dry season from March to August and a wet season from December to February.

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The yearly rainfall ranges from 2,500 - 3,500 mm and the daily temperature ranges from 15 - 28 °C (MCM, 1997).

Like most abandoned mines, the former Mamut Copper Mine has caused environmental problems including dust pollution, soil erosion and soil run-off into the surrounding rivers. Although the mining company took the initiative to rehabilitate waste rock dumps with grasses, legumes and trees, most areas have not undergone rehabilitation and remain devoid of vegetation (MCM, 1997; Jopony & Tongkul, 2004). There are still large areas that are bare without vegetation especially at the slopes and benches of the West Dump and Nasapang Dump. Any plants surviving in these areas have a potential use for rehabilitation programme of the former mine.

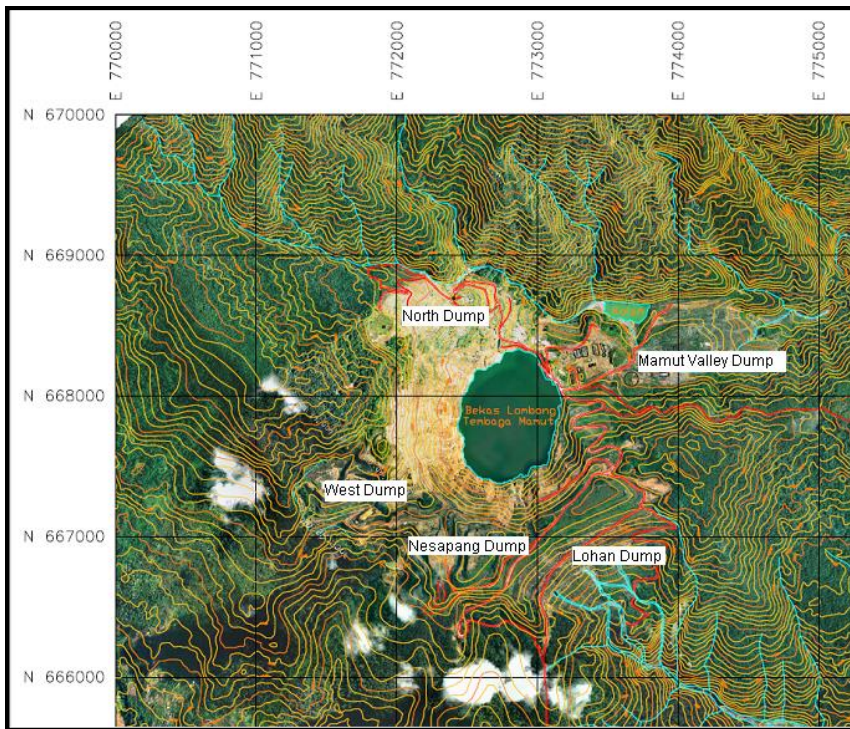


Figure 1. The locations of waste rock dumps at the former Mamut Copper Mine (Source: JMG, 2009)

Materials and Methods

Several visits were made to the former mine from April to August 2009. An attempt has been made to cover all areas of the dumps sites. The plant sample collections were grouped into four on the basis of the growth form: trees (≥ 10 cm diameter at breast height), shrubs (< 10 cm dbh), herbaceous plants and graminoids. Each group was collected and voucher specimens deposited at BORH (UMS herbarium), SAN (Sandakan herbarium) and SNP (Sabah Parks herbarium).

All oven-dried specimens were sorted according to morpho-species and identified to species-level by cross-checking with existing specimens at the BORH, SAN and SNP herbariums. Flora reference books were used in the identification processes (Airy Shaw, 1975; Argent *et al.*, 2007; Soepadmo, *et al.*, 1995; 1996; 2000; 2002; 2004; 2007; Sugau, 2008).

Results and Discussion

The original forest cover of the abandoned Mamut Copper Mine was the upper part of the lower montane forest on ultramafic soil. This forest is an Oak-laurel forest (Fagaceae and Lauraceae) and Ericaceous forest (Conifers, Myrtaceae and Ericaceae). This is evident from the surrounding forests. Unfortunately, the original forest cover of the abandoned Mamut Copper Mine has long disappeared due to the copper mining activity. The area is currently abandoned and is being slowly colonized by pioneer montane plant species. The surrounding forests fortunately serve as seed source to the abandoned mine site. Seedlings and saplings of forest species were encountered in the survey areas, such as *Phyllocladus hypophyllus* and *Tristaniopsis whaetiana*. A detailed list of all the plant species found during the surveys from each of the dumpsites is listed in tables 1, 2 and 3. Most of the specimens were identified to species level. However, 13 specimens were identified up to genus-level only and four specimens remain unidentified.

The total number of species found at the abandoned Mamut Copper Mine totals 204 represented by 73 families and 152 genera (Table 4). Of these, 59 are tree species, 55 are shrub species, 64 are herbaceous species (including ferns), 23 species of graminoids, and two different moss species. The total number of voucher/herbarium specimens is 156.

Not all of the species found in this study are native to Sabah. Some species were introduced either for rehabilitation or for other purposes. A shrub,

Allamanda cathartica (Apocynaceae) and eight trees species were identified as introduced species: *Mangifera indica* (Anacardiaceae), *Psidium guajava* and *Eucalyptus robusta* (Myrtaceae), *Artocarpus odoratissimus* (Moraceae), *Acacia mangium*, *Leuceana leucocephala* and *Paraserianthes falcataria* (Leguminosae), and *Pinus caribea* (Pinaceae). In addition, there is a tree species that is naturalized: *Sambucus javanica* (Caprifoliaceae).

The most common tree and shrub species found frequently (≥ 4) in different dump sites include: trees such as *Adinandra excelsa* (Pentaphylaceae), *Duabanga mollucana* (Sonneratiaceae), *Gymnostoma nobile* (Casuarinaceae), *Litsea cubeba* (Lauraceae), *Macaranga kinabaluensis* (Euphorbiaceae), *Neonauclea artocarpoides* and *Neonauclea gigantea* (Rubiaceae), *Pinus caribea* (Pinaceae), *Pittosporum resiniferum* (Pittosporaceae), *Tristaniopsis whaetiana* (Myrtaceae), *Vaccinium retivenium* (Ericaceae) and *Wightia borneensis* (Schrophulariaceae); shrubs namely *Blumea arnakidophora* (Asteraceae), *Schefflera calyptrate* (Araliaceae) and *Vaccinium retivenium* (Ericaceae).

The most common herbaceous plants are ferns like *Aglaomorpha brooksii* (Polypodiaceae), *Blechnum orientale* (Blechnaceae), *Christella arida* (Thelypteridaceae), *Dicranopteris clemensiae* (Gleicheniaceae) and *Pityrogramma calomelanos* (Adiantaceae); orchids including *Dilochia wallichii* (Orchidaceae), *Arundina graminifolia* (Orchidaceae) and *Dendrochilium crissum* (Orchidaceae); and others namely *Nepenthes stenophylla* (Nepenthaceae), *Polygala paniculata* (Polygalaceae), and *Rhaucophica javanica* (Hemerocallidaceae).

Table 1. List of trees and shrub species occurring at the former Mamut Copper Mine
 ND = North Dump, WD = West Dump, NSD = Nasapang Dump, MVD = Mamut Valley Dump, LD = Lohan Dump, t = tree, sh = shrub, sc = scrambler

Family	Species	Voucher	Habit	ND	WD	NSD	MVD	LD
Anacardiaceae	<i>Mangifera indica</i>	Mesen 15	t				J	
Apocynaceae	<i>Allamanda cathartica</i>	PS02	sh				J	
Apocynaceae	<i>Alstonia angustifolia</i>	Nspg 18	t		J		J	
Apocynaceae	<i>Alstonia iwahigensis</i>	Nspg 17	t			J		
Apocynaceae	<i>Alstonia scholaris</i>	W 18	t			J		
Asteraceae	<i>Blumea arnakidaphora</i>	N 8; Mesen 16; W 17	sh	J	J		J	
Asteraceae	<i>Blumea balsamifera</i>	PS04	sh				J	
Asteraceae	<i>Chromolaena odorata</i>	M 3	sh				J	
Asteraceae	indet.	W 13; Nspg 1; N 11	t	J		J		
Asteraceae	<i>Vernonia arborea</i>	L 9; Nspg 31; L 2	t		J	J		J
Aquifoliaceae	<i>Ilex spicata</i>	W 2; Nspg 37	t	J	J	J	J	
Araliaceae	<i>Aralia Montana</i>	M 25	t				J	
Araliaceae	<i>Schefflera calyptrata</i>	Nspg 38; N 6; W 47	sc	J	J	J	J	
Araliaceae	<i>Schefflera lanata</i>	Nspg 48	sh				J	
Araliaceae	<i>Schefflera lineamentorum</i>	N 16	sh	J				
Araliaceae	<i>Schefflera ridleyi</i>	W 23	sh		J			
Bignoniaceae	<i>Radermachera pinnata</i>	W 45	t		J		J	
Caprifoliaceae	<i>Sambucus Javanica</i>	Mesen 19	t				J	
Casuarinaceae	<i>Gymnostoma nobile</i>	Nspg 15; M 1	t	J		J	J	J
Cecropiaceae	<i>Poikilospermum scabrinervium</i>	N26, PS56, W41	sh	J	J		J	
Cecropiaceae	<i>Poikilospermum suaveolens</i>	N12	sc	J			J	
Celastraceae	<i>Perrottetia alpestris</i>	M 12; M 4; M 19	sh				J	
Clethraceae	<i>Clethra pachyphylla</i>	W 16; N 4	t	J	J		J	
Convolvulaceae	<i>Merremia</i> sp	PS14	sc				J	
Crypteroniaceae	<i>Crypteronia paniculata</i>	Nspg 14; W 51	t		J	J		
Cunoniaceae	<i>Weinmannia fraxinea</i>	Nspg 6; W 15	t		J	J		
Cyatheaceae	<i>Cyathea contaminans</i>	seen	t				J	
Elaeocarpaceae	<i>Elaeocarpus angustipes</i>	W 27	t		J			
Elaeocarpaceae	<i>Elaeocarpus murudensis</i>	W 1	t		J			
Ericaceae	<i>Diplycosia pinifolia</i>	W 10	sc		J			
Ericaceae	<i>Rhododendron baconii</i>	Nspg 21	sh				J	
Ericaceae	<i>Rhododendron borneensis</i>	W 26	sh		J			
Ericaceae	<i>Rhododendron ericoides</i>	Nspg 10	sh				J	

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Table 1. (continued)

Family	Species	Voucher	Habit	ND	WD	NSD	MVD	LD
Ericaceae	<i>Rhododendron fallacinum</i>	W 19	sh		J			
Ericaceae	<i>Rhododendron javanicum</i> ssp. <i>Kinabaluense</i>	W 50	sh	J	J			
Ericaceae	<i>Rhododendron praetervisum</i>	Nspg 32; N 15; W 21	sh	J	J	J		
Ericaceae	<i>Rhododendron scrobiculatum</i>	Nspg 8; W 22	sh	J	J	J		
Ericaceae	<i>Vaccinium cloaxylon</i>	W 6	sh	J				
Ericaceae	<i>Vaccinium clementis</i>	W 15; Nspg 12	sh	J	J	J		
Ericaceae	<i>Vaccinium retivenium</i>	Mesen 3; L 7; W2 0; N 19	sh	J	J	J		J
Ericaceae	<i>Vaccinium simulans</i> var. <i>leptopodium</i>	Nspg 23	sh			J		
Euphorbiaceae	<i>Homalanthus populneus</i>	Mesen 10	t				J	
Euphorbiaceae	indet.	Nspg 29				J		
Euphorbiaceae	<i>Macaranga cf. curtisii</i>	W 11	t		J			
Euphorbiaceae	<i>Macaranga kinabaluensis</i>	Mesen 4; Nspg 36; L 12	t	J	J	J		J
Euphorbiaceae	<i>Macaranga winkleri</i>	N 9	t	J				
Gesneriaceae	<i>Aeschynanthus magnificus</i>	N 23	sh	J				
Gesneriaceae	<i>Cyrtandra chrysea</i>	W 5	sh		J			
Ixonanthaceae	<i>Ixonanthes reticulata</i>	Mesen 23	t				J	
Juglandaceae	<i>Engelhardtia serrata</i>	M 20	t				J	
Lauraceae	<i>Litsea cubeba</i>	W 46; L 11; Mesen 5; N 17	t	J	J	J		J
Lauraceae?	indet.	W 28	t		J			
Leguminosae	<i>Acacia mangium</i>	seen	t				J	
Leguminosae	<i>Alysicarpus vaginalis</i>	PS21	sh				J	
Leguminosae	<i>Archidendron clyperia</i>	N 7	sh	J				
Leguminosae	<i>Centrosema pubescens</i>	PS20	sh				J	
Leguminosae	<i>Crotalaria pallida</i>	M 22	sh				J	
Leguminosae	<i>Desmodium purpureum</i>	PS24, MV04, W11	sh	J	J		J	
Leguminosae	indet.	W13	sh		J			
Leguminosae	<i>Leucecena leucocephala</i>	Nspg 20; Mesen 6	t			J	J	
Leguminosae	<i>Macroptilium atropureum</i>	PS22, Ng13, L12, MV05	sc			J	J	J
Leguminosae	<i>Paraserianthes falcataria</i>	seen	t				J	J
Leguminosae	<i>Desmodium congesta</i>	M 22					J	J

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Table 1. (continued)

Family	Species	Voucher	Habit	ND	WD	NSD	MVD	LD
Loganiaceae	<i>Buddleja asiatica</i>	M 24	sh				<i>f</i>	
Loganiaceae	<i>Fagraea collina</i>	Nspg 16; W 42	t	<i>f</i>	<i>f</i>	<i>f</i>		
Melastomataceae	<i>Medinella beamanii</i>	W 49	sh	<i>f</i>	<i>f</i>	<i>f</i>		
Melastomataceae	<i>Medinella speciosa</i>	N 1	sh	<i>f</i>			<i>f</i>	
Melastomataceae	<i>Melastoma beccarianum</i>	M 5	sh				<i>f</i>	
Melastomataceae	<i>Melastoma malabatricum</i>	W 25; Nspg 28; N 25	sh	<i>f</i>	<i>f</i>	<i>f</i>		
Moraceae	<i>Artocarpus odoratissimus</i>	Mesen 12	t				<i>f</i>	
Moraceae	<i>Ficus macilenta</i> var. <i>ilicifolia</i>	W 37; Nspg 33	sc	<i>f</i>	<i>f</i>	<i>f</i>		
Moraceae	<i>Ficus oleaeifolia</i>	Nspg 2	t				<i>f</i>	
Moraceae	<i>Ficus septica</i>	Mesen 13	t				<i>f</i>	
Moraceae	<i>Ficus setiflora</i> var. <i>adelpha</i>	W 24	sh	<i>f</i>				
Myricaceae	<i>Myrica esculenta</i>	Nspg 9	t				<i>f</i>	
Myrsinaceae	<i>Embelia dasythyra</i>	W19	Sc	<i>f</i>				
Myrsinaceae	<i>Myrsine porteriiana</i>	W 52	t	<i>f</i>				
Myrtaceae	<i>Decaspermum fruticosum</i>	M 13	t				<i>f</i>	
Myrtaceae	<i>Eucalyptus robusta</i>	Mesen 18	t				<i>f</i>	
Myrtaceae	<i>Psidium guajava</i>	Mesen 8	t				<i>f</i>	
Myrtaceae	<i>Syzygium grande</i>	W 34	t	<i>f</i>				
Myrtaceae	<i>Tristaniopsis whaetiana</i>	W 39; L 1; Nspg 11; N 12	t	<i>f</i>	<i>f</i>	<i>f</i>	<i>f</i>	<i>f</i>
Pentaphylacaceae	<i>Adinandra collina</i>	L 13; Nspg 35; W 14	t	<i>f</i>	<i>f</i>	<i>f</i>		<i>f</i>
Pentaphylacaceae	<i>Adinandra cordifolia</i>	Nspg 30	t				<i>f</i>	
Pentaphylacaceae	<i>Adinandra excelsa</i>	Mesen 2; W 3; N 22	t	<i>f</i>	<i>f</i>	<i>f</i>		
Pentaphylacaceae	<i>Adinandra impressa</i>	Nspg 3	t				<i>f</i>	
Pentaphylacaceae	<i>Ternstroemia lowii</i>	Nspg 24; W 9	t	<i>f</i>	<i>f</i>	<i>f</i>	<i>f</i>	
Pinaceae	<i>Pinus caribea</i>	W 30; Mesen 17; N 5	t	<i>f</i>	<i>f</i>	<i>f</i>	<i>f</i>	
Pittosporaceae	<i>Pittosporum ferrugineum</i>	Nspg 13	t				<i>f</i>	
Pittosporaceae	<i>Pittosporum resiniferum</i>	Mesen 9; Nspg 26; N 18	t	<i>f</i>	<i>f</i>	<i>f</i>	<i>f</i>	
Podocarpaceae	<i>Dacrydium xantandrum</i>	W 4	t	<i>f</i>				
Podocarpaceae	<i>Phyllocladus hypophyllus</i>	W 7; Nspg 25	t	<i>f</i>	<i>f</i>	<i>f</i>	<i>f</i>	
Podocarpaceae	<i>Dacrydium</i> cf. <i>pectinatum</i>	W 10	t	<i>f</i>				
Polygonaceae	<i>Polygonum chinensis</i>	Mesen 14	sc				<i>f</i>	
Polygonaceae	<i>Polygonum lapathifolium</i>	PS48	sc				<i>f</i>	
Rosaceae	<i>Rubus fraximifolius</i>	L 3; N 14	sh	<i>f</i>	<i>f</i>	<i>f</i>	<i>f</i>	<i>f</i>
Rosaceae	<i>Rubus mollucanus</i>	MV18, N25, PS52	sh	<i>f</i>	<i>f</i>	<i>f</i>	<i>f</i>	
Rubiaceae	<i>Neonauclea artocarpoides</i>	L 5; Nspg 7; W 38	t	<i>f</i>	<i>f</i>	<i>f</i>	<i>f</i>	<i>f</i>
Rubiaceae	<i>Neonauclea gigantea</i>	L6; Nspg 5; W 33	t	<i>f</i>	<i>f</i>	<i>f</i>	<i>f</i>	<i>f</i>

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Table 1. (continued)

Family	Species	Voucher	Habit	ND	WD	NSD	MVD	LD
Rubiaceae	<i>Paederia foetida</i>	W38	sh		/			
Rubiaceae	<i>Wendlandia paniculata</i>	Nspg 22	t			/		
Schrophulariaceae	<i>Wightia borneensis</i>	L 8; W 31; N 24	t	/	/	/	/	/
Smilacaceae	<i>Smilax leavis</i>	W39	sc		/			
Sonneratiaceae	<i>Duabanga mollucana</i>	L 10; Mesen 7; L 4	t				/	/
Theaceae	<i>Schima brevifolia</i>	W 12	t		/			
Theaceae	<i>Schima wallichii</i>	N 20	t	/				
Thymelaeaceae	<i>Wikstroemia</i> sp.	M 11	sh				/	
Ulmaceae	<i>Trema tomentosa</i>	Mesen 1	t				/	
Urticaceae	<i>Debregeasia longifolia</i>	Mesen 11	sh	/			/	
Urticaceae	<i>Leucosyke capitellata</i>	M 16	t				/	
Urticaceae	<i>Pouzolzia sanguinea</i>	Mesen 20	sh				/	
Verbenaceae	<i>Lantana camara</i>	M 18	sh				/	
Vitaceae	<i>Tetrastigma papillosum</i>	MV19, PS57	sc				/	
Winteraceae	<i>Drymis piperita</i>	W 35	t		/			

Table 2. List of herbaceous species occurring at the former Mamut Copper Mine
 ND = North Dump, WD = West Dump, NSD = Nasapang Dump, MVD = Mamut Valley Dump, LD = Lohan Dump, h = herb.

Family	Species	Voucher	Habit	ND	WD	NSD	MVD	LD
Adiantaceae	<i>Pityrogramma calomelanos</i>	W01, L 01, g01, PS01, MV01	h		✓	✓	✓	✓
Araceae	<i>Scindapsus kinabaluensis</i>	L36	h					✓
Asteraceae	<i>Bidens pilosa</i>	PS06, W07	h		✓		✓	
Asteraceae	<i>Conyza bonariensis</i>	L03	h					✓
Asteraceae	<i>Conyza sumatrensis</i>	PS03	h				✓	
Asteraceae	<i>Crassocephalum crepidioides</i>	PS08, Ng03, W04	h		✓	✓	✓	
Asteraceae	<i>Gynura sarmentosa</i>	L02	h					✓
Asteraceae	<i>Hypochoeris radicata</i>	Ng02, L04	h			✓		✓
Asteraceae	<i>Mikania micrantha</i>	PS10, W06	h		✓		✓	
Asteraceae	<i>Sonchus</i> sp	PS11, MV02, L05	h				✓	✓
Asteraceae	<i>Wedelia trilobata</i>	PS09	h				✓	
Begoniaceae	<i>Begonia cucullata</i>	N01	h	✓				
Blechnaceae	<i>Blechnum orientale</i>	L07, PS12, MV03, W08, N02	h	✓	✓	✓	✓	✓
Convolvulaceae	<i>Ipomoea cairica</i>	Ng06, PS13	h				✓	
Davalliaceae	<i>Davallia denticulata</i>	L08, Ng08	h			✓	✓	✓
Davalliaceae	<i>Davallia</i> sp	Ng09, N04	h	✓		✓		
Dennstaedtiaceae	<i>Histiopteris incisae</i>	W10, L09	h		✓			✓
Dennstaedtiaceae	<i>Pteridium esculentum</i>	L10	h					✓
Dennstaedtiaceae	<i>Sphenomeris chinensis</i>	N05, Ng10	h			✓		
Dicksoniaceae	<i>Cibotium arachnoideum</i>	Ng10	h			✓		
Dipteridaceae	<i>Dipteris conjugata</i>	Ng12	h			✓		
Equisetaceae	<i>Equisetum romosissimum</i>	PS18	h				✓	
Gleicheniaceae	<i>Dicranopteris clemensiae</i>	PS25, W16, L13, Ng14	h		✓	✓	✓	✓
Gleicheniaceae	<i>Diplopterygium</i> sp	W15	h		✓			
Hemerocallidaceae	<i>Rhaucophica javanica</i>	PS26, L25, N19, MV11	h	✓			✓	✓
Hypoxidaceae	<i>Cucurliigo latifolia</i>	Ng15, N09, W17, PS27	h	✓	✓	✓	✓	
Leguminosae	<i>Mimosa pudica</i>	W14, PS23	h		✓		✓	
Lycopodiaceae	<i>Lycopodium cernua</i>	MV06, PS29, L14	h				✓	✓
Lycopodiaceae	<i>Lycopodium clavatum</i>	Ng16, N10	h	✓		✓		
Lythraceae	<i>Cuphea hyssopifolia</i>	PS28	h				✓	
Nepenthaceae	<i>Nepenthes reinwardtiana</i>	PS3, Ng17, MV07	h			✓	✓	✓
Nepenthaceae	<i>Nepenthes burbidgeae</i>	Ng 35	h				✓	
Nepenthaceae	<i>Nepenthes fusca</i>	W22	h		✓			

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Table 2. (Continued)

Family	Species	Voucher	Habit	ND	WD	NSD	MVD	LD
Nepenthaceae	<i>Nepenthes macrovulgaris</i>	L16, W21	h		✓			✓
Nepenthaceae	<i>Nepenthes stenophylla</i>	W42	h		✓			
Nepenthaceae	<i>Nepenthes cordifolia</i>	L17, PS32, Ng19, W23	h		✓	✓	✓	✓
Nepenthaceae	<i>Nepenthes tuberosa</i>	N13, MV08	h	✓				✓
Orchidaceae	<i>Acriopsis cf. javanica</i>	L20	h	✓				
Orchidaceae	<i>Agrostophyllum</i> sp.	N18	h	✓				
Orchidaceae	<i>Arundina graminifolia</i>	PS34, L23, N15, MV10, Ng21	h	✓	✓	✓	✓	✓
Orchidaceae	<i>Coelogyne cf. moultonii</i>	W25	h		✓			
Orchidaceae	<i>Coelogyne clemensii</i>	W26	h		✓			
Orchidaceae	<i>Coelogyne</i> sp	PS37, L19	h				✓	✓
Orchidaceae	<i>Dendrobium</i> sp	L18	h					✓
Orchidaceae	<i>Dendrobium crassum</i>	W29, MV09, Ng20, N14, PS35	h	✓	✓	✓	✓	✓
Orchidaceae	<i>Dilochia wallichii</i>	Ng22, N16, PS33, WZ4, L24	h	✓	✓	✓	✓	✓
Orchidaceae	<i>Eria</i> sp	L22	h					✓
Orchidaceae	<i>Peristylus hallieri</i>	W28	h		✓			
Orchidaceae	<i>Phaius tankervilleae</i>	PS38	h					
Orchidaceae	<i>Spathoglottis aurea</i>	PS36, W27	h		✓		✓	
Orchidaceae	<i>Spathoglottis</i> cf. <i>microchilina</i>	N17	h	✓				
Orchidaceae	<i>Thrixpernum</i> sp	L21	h					✓
Polygaceae	<i>Polygala paniculata</i>	MV16, Ng28, W32, PS47	h		✓	✓	✓	✓
Polyodiaceae	<i>Aglaomorpha brooksii</i>	PS50, MV17, L33, W36	h		✓		✓	✓
Polyodiaceae	<i>Belvisia callifolia</i>	N24	h	✓				
Polyodiaceae	<i>Belvisia revolta</i>	N23	h	✓				
Polyodiaceae	<i>Belvisia spicata</i>	PS49, W34	h		✓		✓	
Polyodiaceae	<i>Goniophlebium pecussum</i>	W35	h		✓			
Polyodiaceae	<i>Microsorium membranifolium</i>	Ng29	h			✓		
Polyodiaceae	<i>Pyrrosia lanceolata</i>	N22	h	✓				
Polyodiaceae	<i>Pyrrosia rasamatae</i>	Ng30, PS51	h			✓	✓	
Schizaeaceae	<i>Lygodium</i> cf. <i>microphyllum</i>	PS54	h					✓
Thelypteridaceae	<i>Christella arida</i>	W40, Ng33, PS55	h		✓	✓	✓	✓
Zingiberaceae	<i>Hedygium cylindricum</i>	Ng34, PS58, L35, N27	h	✓	✓	✓	✓	✓

Table 3: List of grasses and mosses occurring at the former Mamut Copper Mine
 ND = North Dump, WD = West Dump, NSD = Nasapang Dump, MVD = Mamut Valley Dump, LD = Lohan Dump, g = grass, m = mosses

Family	Species	Voucher	Habit	ND	WD	NSD	MVD	LD
Cyperaceae	<i>Cyperus kyllingia</i>	Jg01	g	✓			✓	
Cyperaceae	<i>Fimbristylis littoralis</i>	Jg02	g				✓	
Cyperaceae	<i>Fuirena umbellata</i>	Jg03	g	✓			✓	
Cyperaceae	<i>Gahnia javanica</i>	Jg04	g	✓	✓	✓		
Cyperaceae	<i>Hypolytrum nemorum</i>	Jg05	g	✓			✓	
Cyperaceae	<i>Scirpus mucronatus</i>	Jg06	g	✓			✓	
Cyperaceae	<i>Eleocharis</i> sp	Jg25	g				✓	
Cyperaceae	<i>Schoenopteris juncooides</i>	Jg26	g	✓			✓	
Poaceae	<i>Axonopus compressus</i>	Jg08	g	✓	✓	✓	✓	
Poaceae	<i>Coix lacryma-jobi</i>	Jg09	g	✓			✓	
Poaceae	<i>Cynodon dactylon</i>	Jg10	g	✓			✓	
Poaceae	<i>Cyperus odoratus</i>	Jg11	g	✓			✓	
Poaceae	<i>Digitaria junghumiana</i>	Jg12	g	✓			✓	
Poaceae	<i>Eragrostis atrovirens</i>	Jg13	g	✓	✓	✓	✓	✓
Poaceae	<i>Imperata cylindrica</i>	Jg14	g	✓	✓	✓	✓	✓
Poaceae	<i>Leptochloa</i> sp.	Jg15	g	✓				
Poaceae	<i>Miscanthus floridulus</i>	Jg16	g	✓	✓	✓	✓	✓
Poaceae	<i>Panicum sarmentosum</i>	Jg17	g	✓			✓	
Poaceae	<i>Paspalum conjugatum</i>	Jg18	g	✓	✓	✓	✓	
Poaceae	<i>Pogonatherum crinitum</i>	Jg19	g	✓	✓	✓	✓	✓
Poaceae	<i>Setaria sphacelata</i>	Jg20	g	✓	✓	✓	✓	
Poaceae	<i>Thyrsanolaena latifolia</i>	Jg21	g	✓	✓	✓	✓	✓
Poaceae	<i>Bathriocloa</i> sp	Jg27	g	✓	✓	✓	✓	
Thypaceae	<i>Thypha angustifolia</i>	Jg22	g	✓			✓	
Dicranaceae	<i>Campylopus umbellata</i>	Jg23	m			✓	✓	✓
Dawsoniaceae	<i>Dawsonia beccarii</i>	Jg24	m			✓		✓

Table 4. List of plant families occurring at the former Mamut Copper Mine

No.	Family	No. of Genera	No. of Species
1	Adiantaceae	1	1
2	Anacardiaceae	1	1
3	Apocynaceae	2	4
4	Aquifoliaceae	1	1
5	Araceae	1	1
6	Araliaceae	2	5
7	Asteraceae	11 (1 indet)	13
8	Begoniaceae	1	1
9	Bignoniaceae	1	1
10	Blechnaceae (ferns)	1	1
11	Caprifoliaceae	1	1
12	Casuarinaceae	1	1
13	Cecropiaceae	1	2
14	Celastraceae	1	1
15	Clethraceae	1	1
16	Convolvulaceae	2	2
17	Crypteroniaceae	1	1
18	Cunoniaceae	1	1
19	Cyatheaceae (ferns)	1	1
20	Cyperaceae	8	8
21	Davaliaceae (ferns)	1	2
22	Dennstaedtiaceae (ferns)	3	3
23	Dicksoniaceae (ferns)	1	1
24	Dicranaceae (Mosses)	1	1
25	Dipteridaceae (ferns)	1	1
26	Dowsoniaceae (Mosses)	1	1
27	Elaeocarpaceae	1	2
28	Equisetaceae (ferns)	1	1
29	Ericaceae	3	12
30	Euphorbiaceae	2 (1 indet)	4
31	Fabaceae	10 (1 indet)	12
32	Gesneriaceae	2	2
33	Gleicheniaceae (ferns)	2	2
34	Hemerocallidaceae	1	1
35	Hypoxidaceae	1	1
36	Ixonanthaceae	1	1
37	Juglandaceae	1	1
38	Lauraceae	1 (1 indet)	1
39	Loganiaceae	2	2
40	Lycopodiaceae (ferns)	1	2
41	Lytraceae	1	1
42	Melastomataceae	2	4
43	Moraceae	2	5
44	Myricaceae	1	1
45	Myrsinaceae	2	2
46	Myrtaceae	5	5
47	Nepenthaceae	1	5
48	Nephrolepidaceae (ferns)	1	2
49	Orchidaceae	12	15
50	Pentaphragmaceae	2	5
51	Pinaceae	1	1
52	Pittosporaceae	1	2
53	Poaceae	15	15
54	Podocarpaceae	1	2
55	Polygalaceae	1	1
56	Polygonaceae	1	2

(continued on next page)

Table 4. (Continued)

No.	Family	No. of Genera	No. of Species
57	Polypodiaceae (ferns)	5	8
58	Rosaceae	1	2
59	Rubiaceae	4	4
60	Schizaeaceae (ferns)	1	1
61	Schrophulariaceae	1	1
62	Smilacaceae	1	1
63	Sonneratiaceae	1	1
64	Theaceae	1	2
65	Thelypteridaceae (ferns)	1	1
66	Thymelaeaceae	1	1
67	Thypaceae	1	1
68	Ulmaceae	1	1
69	Urticaceae	3	3
70	Verbenaceae	1	1
71	Vitaceae	1	1
72	Winteraceae	1	1
73	Zingiberaceae	1	1
	TOTAL	152	200

Conclusions

This study has identified 25 plant species that are frequently found on the waste dumpsites and at the former mine. These species are: trees such as *Adinandra excelsa*, *Duabanga mollucana*, *Gymnostoma nobile*, *Litsea cubeba*, *Macaranga kinabaluensis*, *Neonauclea artocarpoides*, *Neonauclea gigantea*, *Pinus caribea*, *Pittosporum resiniferum*, *Tristaniopsis whaetiana* and *Wightia borneensis*; shrubs including *Blumea arnakidophora*, *Schefflera calyptrate* and *Vaccinium retivenium*; ferns namely *Aglaoomorpha brooksii*, *Blechnum orientale*, *Christella arida*, *Dicranopteris clemensiae* and *Pityrogramma calomelanos*; orchids like *Arundina graminifolia*, *Dendrochillum crissum* and *Dilochia wallichii*; and other herbs namely *Nepenthes stenophylla*, *Polygala paniculata* and *Rhaucophica javanica*.

This information can be used for a rehabilitation programme of the former mine. The advantage of using existing plants is that they are pre-adapted to climatic and soil conditions at the site. Further assessments of these plants in the laboratory and field studies would be useful.

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