A DEMONSTRATION PROJECT FOR AFFORESTATION OF DENUDED TIN TAILINGS IN PENINSULAR MALAYSIA

Proyecto de demostración de reforestación en minas de estaño abandonadas y desarboladas en Malaysia peninsular

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Resumen

Desde loa años 30, la extracción de estaño en la Península Malaya ha provocado la creación de aproximadamente 113.700 ha de terrenos mineros abandonados. Grandes extensiones de terrenos degradados, previamente ocupados por bosques bajos de dipterocarpáceas, permanecen todavía yermos. Sólo alrededor del 9,7% de estos antiguos terrenos se ha transformado en suelo urbanizado, cultivos de frutales, granjas agrícolas, parques o campos de golf. Estos terrenos mineros abandonados consisten en restos de arena y lodos. La arena es estéril y tiene un microclima severo. Mientras que, el lodo tiene una mayor fertilidad que la arena pero está normalmente encharcado. Ambos tipos de restos de estaño requieren una mejora adicional para poder ser adecuados para ser usados como materiales para la producción de madera de alto valor. El Forest Research Institute Malaysia (FRIM) ha alquilado el terreno de una antigua mina del Perak State Government para su rehabilitación con especies de alto valor maderero. La extensión de las antiguas minas de estaño es de 121,4 ha y alrededor del 58% de la superficie ha sido plantada con esas especies. *Hopea odorata, Swietenia macrophylla, Acacia híbrida* y *Acacia crassicarpa* se han desarrollado adecuadamente sobre restos arenosos. Otras especies como *Dryas costula, Hopea odorata, Fragea crenulata* y *Khaya ivoriensis* se han desarrollado bien sobre restos de lodos. Además de estas especies de alto valor maderero, otras especies para la obtención de pulpa de celulosa, tales como *Acacia mangium* y *A. auriculiformis* viven en ambos tipos de sustratos. El grado de supervivencia y el incremento medio anual en altura de las especies madereras varía entre el 40 y el 90% y de 0,3 a 2,5 m.año^{-1}, respectivamente. Algunas de los rodales de *Acacia mangium* se plantaron con un sotobosque de *Eurycoma longifolia,* especie de alto valor medicinal. Los objetivos de este artículo se orienta a [1]las técnicas empleadas para mejorar los adversos condicionantes físicos y químicos de los restos de la minería del estaño al objeto de plantar especies de alto valor maderero, [2] la supervivencia y grado de crecimiento de las especies plantadas en stos medios y finalmente [3] destacar los beneficios de los antiguos terrenos de la minería del estaño como áreas productoras de madera.

Palabras clave: *Terrenos mineros abandonados, Reforestación, Especies de alto valor maderero, Rehabilitación, Técnicas de mejora de la estación*

ISSN: 1575-2410

Abstract

Tin mining activities in Peninsular Malaysia since the 1930's, has resulted in ex-mining land covers approximately 113,700 ha. Large tracts of these degraded former lowland dipterocarps forests remain idle till this day. Only about 9.7% of the ex-mining land has been converted into housing estates, fruit orchards, vegetable farms, recreational parks, and golf courses. Ex-mining land consists of sand and slime tailings. The sand is infertile and has harsh microclimate. Whereas, slime which is a more fertile site than sand but is normally water-logged. Both types of tin tailings require further improvement before they can be suitably used as high value timber production sites. FRIM has leased a piece of ex-mining land from Perak State Government to rehabilitate with high value timber tree species. The extent of the tin tailings is 121.4 ha and about 58% of the area had been planted with high value timber tree species. *Hopea odorata, Swietenia macrophylla, Acacia hybrid,* and *Acacia crassicarpa* have been successfully grown on sand tailings. Other high value timber species such as *Dyera costula, Hopea odorata, Fagraea crenulata,* and *Khaya ivorensis* grown well on slime tailings. In addition to the high value timber species, other pulpwood species such as *Acacia mangium* and *Acacia auriculiformis* are grown on both types of tailings. The survival and mean annual height increment of timber species ranging from 40 to 90%, and 0.3 to 2.5 m y^{-1} were recorded respectively. Some of the Acacia mangium stands were under-planted with high value medicinal herbs *Eurycoma longifolia.* This paper aims to discuss on [1] techniques employed to improve physical impediments and chemical adversity of tin tailings for the establishment of high value timber species, [2] the survival and growth of the timber species grown on tin tailings, and lastly [3] to highlight the benefits of tin tailings as a timber production area.

Key words: *Ex-mining land, Afforestation, High value timber species, Rehabilitation, Site improvement techniques*

INTRODUCTION

The ex-mining land in Peninsular Malaysia covers approximately 113,700 ha (CHAN, 1990) comprising tin tailings (85.6%) and water bodies (14.4%). CHAN (1990) showed that only 4,730 ha (4.2%) of the ex-mining land had been utilised for agriculture and 5.5 % for other uses. However, the excessive uptake of heavy metals in the agricultural produces cultivated on tin tailings has rendered the site unsuitable for food crop production (ANG et *al.,* 1998). Hence, large tracts of tin tailings remain unproductive and have great potential for conversion into timber production sites. Research activities focusing on the utilisation of tin tailings for timber production were carried out since the 1960's (MITCHELL, 1957) and a more systematic approach on the research have been conducted recently. In 1997, FRIM leased an ex-mining land resulted from tin mining activities in 1942, from the State Government of Perak (SGP) to establish a small scale forest plantation consisting timber species with end uses ranging from pulpwood to high value cabinet wood and sawn timber. The planted area covers approximately 80 ha of the tin tailings as to-date.

This paper aims to document the establishment of a demonstration project on tree growing on sand tailings and its potential advantages.

MATERIAL AND METHODOLOGY

The project site is located at Bidor (4º06' N latitude, 101º16'E longitude), which was a mining town. The extent of the project site is 121.4 ha and approximately 30% is water bodies and the remaining 85 ha are tin tailings. The site was mined in 1950's by using dredging and gravel pumps methods. The project site was formerly used as grazing ground and dominated by grasses, relics of small pioneer species grown on depressions located at the fringes of ex-mining ponds. Some weather parameters collected from a weather station located in Bidor and about 3 km from the project site are shown in figure 1. The mean total annual rainfall for the period was 4390 ± 1083 mm and indicated that the project site was rather wet.

Techniques of amelioration needed for growing suitable timber species on sand and slime are different. However, amelioration efforts normally focus on two main scopes including [1] improving physical properties of tailing and [2] improving chemical properties of tailings.

Improvement of physical properties of tailings

Both sand and slime tailings require loosening as part of site preparation but for different reasons. High mechanical impedance of sand tailings can be overcome by ploughing to a depth of about 35 to 45 cm by a tractor. Mechanical impedance is also a problem for slime especially during dry season. The cracking of dry slime would normally break the feeder roots and inhibiting the growth of plants. Hence, two rounds of rotovation to a depth of 30 to 40 cm and a round of ploughing before tree planting are required to prevent the cracking of slime during dry seasons.

The seedling was planted in a big planting hole 1 x 1 x 0.5 m where the root-ball was lowered to 45 cm below the surface of the sand. Hence, the root zone loses less water from evapotranspiration. All the timber species established using big-hole planting technique have recorded > 90% survival. Slime has more than 90% of clay and silt particles. This has caused water-logging in slime areas after a rainfall of more than 7 mm/day. For the planting effort to be meaningful the slime must be ploughed as described earlier and made into raised planting bed of about 20 to 25 cm height with 1.5 m width. Construction of a drain with dimensions of 1.5 to 2 m depth x 0.75 to 1m for 20-30 planting beds, leading to existing waterway, proves to be efficient for draining the rainwater during heavy downpour.

Improvement of chemical properties of tailings

Sand and slime have different chemical properties that will affect the growth of timber tree species (ANG & LIM, 1997). Both types of tailings have lowered concentration of macronutrients and some of the important trace elements compared to the mineral soils as shown in table

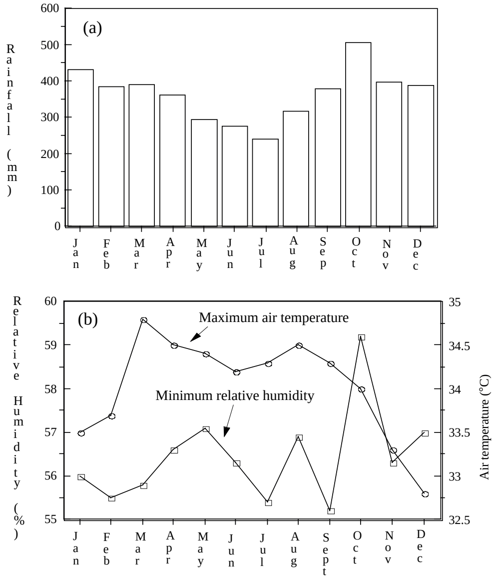

Figure 1. *The mean monthly rainfall (a), mean maximum hourly temperature (b), and mean minimum relative humidity (b) of Bidor for the period of January 1996 to November, 2000 except from April, 1997 to Jun, 1998 for the rainfall data as the raingauge of the weather station was out of order*

1. Organic fertiliser either from plant materials or animal wastes were applied to sand tailings to improve the nutrient status of sand tailings in the project site. The soil pH of the project site is from 4.0 to 6.5, and with the application of about 200 g GML/planting point, the growth of the seedlings was observed to be more healthy at one year after planting.

RESULTS

The species were selected (Tabla 2) and grown in the project site not because of their valuable timber alone but also their good adaptability to the harsh environments of the ex-mining site. The suitability of the tree species grown on the project site can be assessed through their survival and growth rate. The survival and growth rate of suitable species grown on the project are as shown in table 3.

Four main silvicultural activities were carried out in the project site namely wee-

Properties	Durian series [1]	Sand tailings [2]	Slime tailings [3]
Wet pH	4.2	4.2-4.32 4.3-5.1*	3.2 4.0-6.5*
Organic Carbon (%)	1.74	0.042-0.062	1.4
N (%)	0.16	0.012	0.20
Available P (ppm)	5.40	0.48-0.76 <0.01 *	15
Exchangeable cations (m.e/100g soils)			
[K+]	0.28	0.013-0.018 0.012-0.03*	0.19
[Mg++]	0.44	0.03 0.007-0.059*	0.30
[Ca++]	0.26	0.06	0.17
CEC	7.5	1.62-1.92 1.0-1.95*	25.27

Table 1: *Some chemical properties of sand dunes and water-logged slime of ex-mining land. The soil samples were collected at depths of 0-15 to 15-30 cm. Sources: [1] AMIR HUSNI (1983), [2] ANG et al. (1994), [3]LIM et al. (1994), and * Project site*

ding, fertilizer application, pruning, and pest control.

Blanket weeding and circle weeding were employed to control weeds especially at the slime area. Chemical weeding using paraquat dichloride (19% w/w) with the concentration of 10 ml l^{-1} has been carried out. Normally circle weeding of radius 1.5 m is employed to control weeds. In order to prevent the seedlings from injured by the herbicides, the operator must step down the weeds that growing around the seedlings before spraying the chemical. The cost of circle and blanket weeding is currently at USD 0.10/planting point and USD 0.20/planting point, respectively. The intensity of the blanket weeding is only once a year, but circle weeding was carried out quarterly at slime tailing. Only the circle weeding is employed quarterly for tree stand grown at sand tailings.

An application of 10 g NPK (15:15:15) + TE was carried out per planting point at sand tailings immediately after planting. Subsequently, a mixture of 2 kg of empty fruit bunch with 20 g NPK (15:15:15) + TE is applied at per planting

Species	Area (ha)	Tailings	End uses
Swietenia macrophylla	1	Sand	High quality cabinet wood
Hopea odorata	13	Sand,slime	Timber for structure uses and window frame
Acacia mangium, Acacia crassicarpa	5	Sand,slime	Furniture wood, pulpwood
Acacia mangium x *Acacia auriculiformis*	5	Sand,slime	Sawntimber, veneer
Khaya ivorensis	15	Slime	High value cabinet wood and furniture wood
Measopsis eminii, Dyera costulata, Intsia palambanica, Tectona garndis, Dryobalanops oblongifolia	6	Slime	Cabinet wood, veneer, high quality furniture wood, pencil, sawntimber.
Fragraea crenulata	4	Slime	Light coloured cabinet wood
Peronema canescens	1	Slime	High value surface veneer

Table 2. *Timber species grown on tin tailings in the project site in Bidor, FRIM*

Species	Number of trees	Stand age (y)	Survival (%)	Mean Annual Increment (m/y)	Tailings
Swietenia macrophylla	100	2	70	0.6-1.2	Sand
Hopea odorata	100	2	95	1.0-1.8	Sand
Acacia mangium	100	2	50	0.6-1.3	Sand
Acacia mangium x *Acacia auriculiformis*	100	2	65	0.9-1.6	Sand
Khaya ivorensis	80	2	85	0.3-2.1	Slime
Fragraea crenulata	200	2	97	1.2-2.3	Slime
Peronema canecens	200	1	85.4	0.5-2.5	Slime

Table 3. *The survival and mean annual top height increment of some timber species growing on tin tailings of the project site in Bidor, FRIM. The growth plots of size at least 0.1 ha was established for each of the species*

point at 1 month after planting. The organic fertiliser had sustained the healthy growth of all the species as the timber species show no sign of nutrient deficiencies. For tree stands grown on slime tailings, 10 g of NPK (15:15:15) + TE with 100 g of GML are applied in the planting hole before transplanting the seedling from the polythene bag. Biannually, 200-250 g of chicken manure with 30 g of NPK (15:15:15) + TE are broadcasted to each planting point. Beneficial soil microflora and fauna are introduced in the nursery stage, whereby topsoils from the forested areas were used for preparation of potting mixture. Other form of commercial introduction often proves to be costly and not effective.

Pruning is carried out to maintain a crown ratio of 45-50% for all species especially the acacias. Singling is also done for acacias as formation of multiple leaders is normally observed in the project site. The cost of pruning is at USD 0.02 to 0.05 per point depending on the height of pruning. The attack of caterpillar *Attacus atlas* was observed only on *Khaya ivorensis.* The defoliator was controlled through removing it from the infested seedling manually. No other diseases or pests are observed for the tree stands. Some saplings were destroyed by buffaloes, however, the occurrence of attacks have been controlled by daily surveillance.

BENEFITS OF AFFORESTATION OF EX-MINING LAND

Three main advantages of afforestation on ex-mining land are [1] improving the site quality of the ex-mining land, [2] ensuring revenue and environmental services, and lastly [3] reducing the pressure of converting poor stock logged-over forest tropical rain forests to general utility forest plantations.

Improving the site Quality of the Ex-mining Land

Modification of microclimate of the site and improving the site fertility are directly resulted from establishment of forest stand on ex-mining land. Modification of the microclimate will enhance the site suitability for growing more valuable timber species and the value added short-term rotation medicinal herbs, for example, *Eurycoma longifolia* established well under a mixed acacias plots at the project site.

Ensuring revenue and environmental services

Timber species like mahogany grown on the project site can yield good revenue and can be as high as USD 30,000 to 40,000 ha^{-1} at 40 years after planting (ANG & ANG 2000). In addition, environmental services such as carbon sequestration must also be counted in economical terms. WORLD BANK (1991) stated that US 28 t^{-1} of carbon is reasonably conservative estimate of the marginal cost of achieving current global goal. For example, the value of environmental service through carbon sequestration for forest plantation stand that yields total biomass of 201.9 m^3 ha^{-1} would be about USD 5928.4 ha^{-} (ANG & ANG, 2000).

Reducing pressure of converting poor stock logged-over forests to general utility plantation

In Peninsular Malaysia alone, 56,250 ha of poorly stock logged-over tropical rain forests have been converted to *Acacia mangium* plantation under the present compensatory forest plantation program (THAI et *al.*, 1997). The plantation area is still below the targeted size of 188,000 ha. One of the reasons for the shortfall is the lack of suitable land for the establishment of forest plantation. The WORLD BANK (1991) reported that forest plantations look more attractive from the economic point of view provided that they are established on idle lands.

CONCLUSION

The project site will be a demonstration plot for establishment of a small scale forest plantation on ex-mining land. After weighing the feasibility of afforestation of ex-mining land and the advantages associated with it, more such degraded sites should be planted with high value timber species. The project will continue to collect data on all the costs of tending so that a proper economical analysis can be conducted to evaluate its economic feasibility.

Acknowledgements

The authors are grateful to the sponsorship and support provided for this project by Forest Research Institute Malaysia, Forestry and Forest Research Institute of Japan, and the State Government of Perak. To JICA for weather station data.

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