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Revegetation of tin post-mining sites in Bangka Island to enhance soil surface development

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Abstract. Sandy tailing, a by-product of tin processing plant is commonly utilized for land preparation for revegetation. In some cases in the land reclamation, slime (clayey) and lateritic materials are also used. Mining company has an obligation to improve environmental quality by which revegetation is introduced using a variety of introduced fast growing species and local species. In this paper we have examined soil surface development under different plant species in tin post-mining area in Bangka Island. The study was carried out in Air Benuang (planted in2017, *Anacardium,* 1 m height), Air Pelawan 2 (planted in 2017, *Paraserianthes falcataria*, 6 m height), Air Pelawan 1 (planted in 2015, rubber trees, 2 m height), Batu Ampar (2007, *Acacia mangium*, 10 m height), and a secondary forest in Air Mesu. In every site a small pit was excavated and some soil physical properties were analyzed in site as well as in laboratory. The results indicated that surface soil of recently revegetated sites has gradually changed into slightly darker from light yellowish brown (10 YR 6/4) into 10 YR 3/1 owing to such addition of organic matter and topsoil during sites preparation. Meanwhile, for the older site of Batu Ampar remains grey (10 YR 5/1-6/1) due to less incorporation of decomposing litter of *Acacia*. Revegetation also enhances decrease of bulk density with age of reclamation. Water infiltration is likely related to the amount of sand fraction but not with the age of revegetation. We learn from the results that plant selection for revegetation is the key factor to ensure a long-term recovery of soil surface condition.

1. Introduction

Bangka Belitung Islands are famous for tin mining since hundreds of years ago. The history of mining began in the Dutch colonial era in the early 19th century. Tin mining is still ongoing even though not as big as before. Data from the Central Bureau of Statistics of the Bangka Belitung Province show that tin (Sn) production declined from 51,596 tons in 2009 to 15,403 tons in 2013. Mining operations are now also beginning to utilize offshore reserves. Data from PT Timah Tbk shows that tin mining business licenses cover an area of 473,303 hectares.

Revegetation is a common practice implemented by various mining companies in order to improve soil quality. The project also reflects company accountability to law as set out in Undang-undang No 4/2009, Peraturan Pemerintah No 78/2010, Peraturan Menteri ESDM No 26/2018, and Keputusan Menteri ESDM No 1827/2018 (Appendix VI) which clearly requires the parties concerned to return

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soil and land condition as soon as the mining operation finished, for example in Bangka for tin mine [1] coal mine in Indonesia [2] as also applied elsewhere like in South Africa [3].

Revegetation of disturbed sites using a mixture of a large number of plant species is a common practice. Plant species for site rehabilitation may be indigenous or introduced one which is grown in the rehabilitation of a gold mine spoil [4], bauxite mines [5], and a lignite mine [6]. Various cultural practices including fertilizing are usually employed [4,7].

In contrast, natural (spontaneous) rehabilitation may also provide quite satisfactory remediation of disturbed sites. However, in several cases establishment of plant cover by this method may take a considerably longer period. Final note is that outcomes may not be easily predicted due exposure to risk of failure during the long slow development [8]. Some authors who worked on disturbed sites around the world found that natural rehabilitation induces a more stable landscape, owing partly to less compaction by machinery and provides more suitable niches for species diversity on abandoned sites [10–13].

The major aim of this study was to determine the relationships between soil attributes with respect to ages of revegetation and management practice during mined land preparation. The long-term objective is to set up mine site quality index based on soil properties suitable for tin mine site reclamation monitoring and evaluation to support revegetation recovery.

2. Materials and Methods

In this study, four revegatation sites were selected from pre-mined locations in Bangka Island, Bangka Belitung Province, Indonesia (Figure 1). Due to occasionally disturbance, we were only able to include more recently reclaimed sites after tin mining; up to two years after deceased operation before land preparation starts and revegetation follows. The mining company normally use fast growing species together with local indigenous species for greening the places.

2.1. Site description

The sites of this study was divided into four location based on the differences in the age of reclamation. The four locations were 1) the land that has not been mined in Air Mesu forest as a reference 2) the former tin mining land that has been reclaimed for 11 years in Batu Ampar prior to this study, 3) a site has been reclaimed for 3 years in Air Pelawan, and 4) two areas that have been reclaimed for one year in Air Pelawan 2 and Air Benuang with different vegetation.

Current land use in the location of study is dominated by trees (*Acacia, Paraserianthes*, *Hevea brasiliensis*, local species of *jambu monyet (Anacardium)*, pioneered horticulture plant (mostly pineapple) and a variety of grassland and secondary forest in the undisturbed site. Topography is gently slope to undulating. Parent material is belived resulting from granite weathering and sand beaches. There is plenty of field evidence for current and past soil erosion in the catchment area of disturbed sites after revegetation adjacent to Air Mesu forest.

2.2. Methods

Collection of primary data is done directly in the field. First, it is by observing mini pits excavated around 40-cm depth followed by standard profile description included soil layers, soil color, texture, structure, root evidence. Second, taking soil samples with ring samples (7.2 cm diameter, 5 cm height) up to 20 cm depth. Another set of soil samples were taken as intact aggregate for soil stability in the laboratory. Soil samples were taken from 5 observation points for each research site. From each location, soil samples were taken ca. 1 kg for analysis in the laboratory.

Field infiltration in the field using single ring method was measured. Water was supplied from a Marriote tube (ca. 10 litres). Drops of water were recorded. Finally, the result was plotted againts Philip equation [14,15].

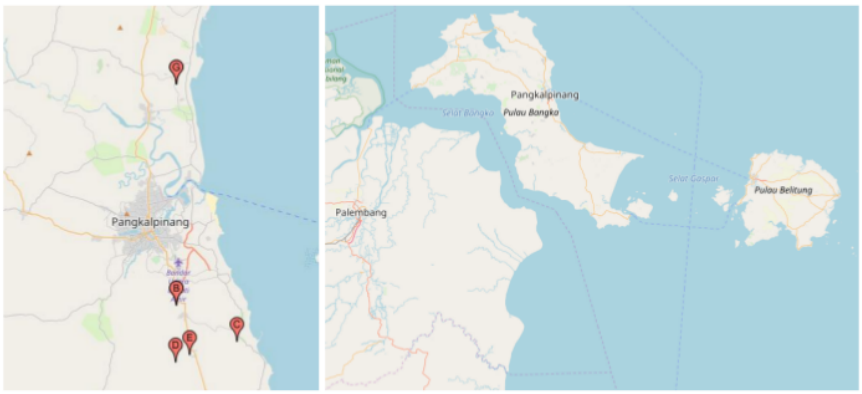


Figure 1. Sampling sites in Bangka Island (B secondary forest in Air Mesu, C Air Benuang, D Air Pelawan 2, E Air Pelawan 1, and G Batu Ampar). Right map is Bangka Belitung Province generated by https://www.geoplaner.com.

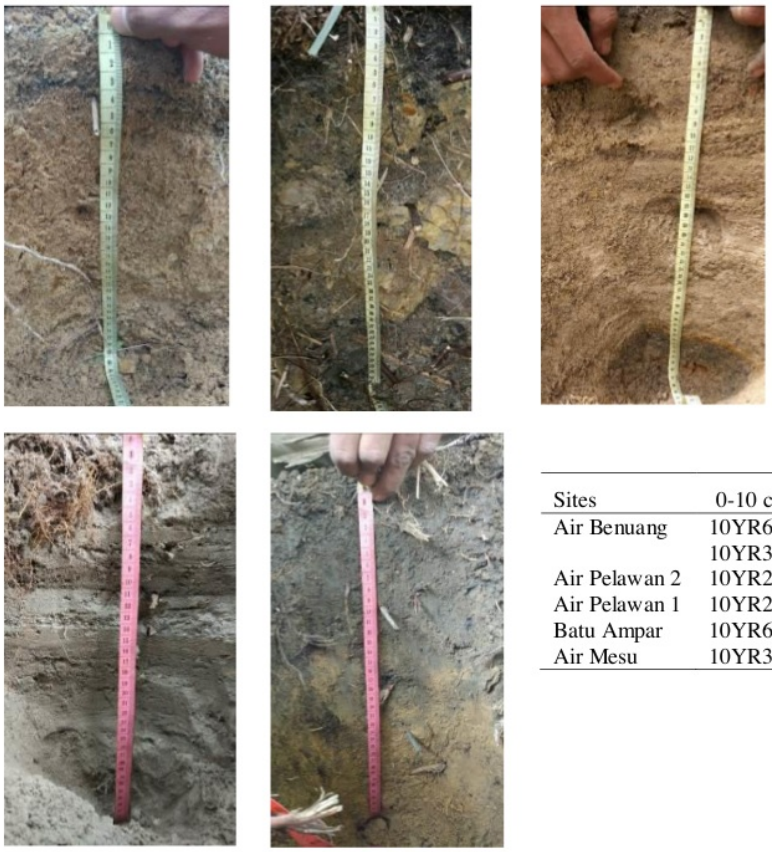
3. Result

Soil texture is the prominent physical proprties of soils in reclaimed mine sites (Table 1). Sandy texture is commonly found as a result of using sand tailings for landscaping. The use of sand tailing resulted in slightly higher bulk density ranging from 1.26 to 1.66 g/cm^3 compared with virgin soil from Air Mesu forest site (1.17 g/cm^3). Parameters of infiltration were much lower for newly reclaimed sites compared with the older sites and forest soil.

Table 1. Texture fractions, bulk density and Philip's parameter of selected sites in Bangka mine sites (values are mean±standard deviation, n=5).

Location	Sand %	Silt %	Clay %	Bulk density (g/cm^3)	Sorptivity (S)	Permeability (K)
Air Benuang 3	84.4±8.1	4.3±4.4	11.3±5.6	1.57±0.12	0.1782±0.1487	0.0092±0.0062
Air Pelawan 1	92.3±1.0	0.4±0.9	7.3±0.9	1.66±0.04	0.0673±0.0851	0.0447±0.0137
Air Pelawan 2	60.4±7.1	12.7±3.3	27.0±4.6	1.52±0.07	0.0633±0.0619	0.0237±0.0252
Batu Ampar	92.3±1.1	0.8±1.1	7.0±0.2	1.26±0.18	0.0888±0.0536	0.0110±0.0040
Air Mesu	68.2±1.3	17.6±2.4	14.1±13.5	1.17±0.04	0.0884±0.0901	0.1659±0.0307

The sign of darkening (braunification) of surface layers due to litter accumulation and decomposition was clear (Figure 2). The color of sand tailing (light yellowish brown, grayish) slowly changes to light brown and even light dark. However, the very slow decomposition of *Acacia* litter exhibits very slow changes in soil color for Batu Ampar in which the original sand tailing remains light gray. Fine root is evident as binding force for sand fraction. We observed water repellency in this very sandy soil.



Sites	0-10 cm	10-20 cm
Air Benuang	10YR6/4-10YR3/1	10YR8/4
Air Pelawan 2	10YR2/1	5Y7/1-10YR7/8
Air Pelawan 1	10YR2/1	5Y6/4
Batu Ampar	10YR6/1	10YR5/1
Air Mesu	10YR3/1	10YR4/2

Figure 2. Morphological features of mini pits representing the sites and secondary forest. Left to right Air Benuang, Air Pelawan 2 and Air Pelawan 2 (top) showing distict layers of newly returned sand tailing; Batu Ampar showing the older sand tailing and Air Mesu (bottom).

4. Discussion

Strategic steps for restoring post-mining land include land management and planting or revegetation. The land management process is primarily intended to create a new safe landscape, characterized by low erosion and rapid infiltration [16]. This is shown by infiltration parameters (sorptivity and permeability) of the reclaimed sites (Table 1). Sandy soils may have Ks values up to 18 cm/hour [9]. Then the ready landscape will be planted with selected plant species in accordance with applicable regulations. The purpose of tree planting, together with land cover crops (generally a legume cover crop) is to accelerate the return of organic matter to the soil. This is important because the sand tailings used in post-mining reclamation are very low in organic matter. Therefore, choosing the right plants and having a large and fast biomass production capacity is very important in the early stages of reclamation [17,18].

An important lesson from this research is the utilization of biomass from plants that have a long life cycle and high litter production. *Acacia* plants with leaves high in cellulose lignin is very slow to decay. Undecay leaves were observed in the soil surface under the *Acacia* which stand for 11 years. Very little change in soil morphology occurs in the soil surface layer. This symptom has actually been studied extensively. Bristow et al. [19] found that *Eucalyptus pellita* and *Acacia peregrina* may be mixed planted to promote biomass production. Passell [20] found slow recovery of reclaimed tin mine

in Bangka being necessary for avifauna. Another result from Kalimantan [21] underlines the effect of fungal infection and insect damage to foliage of Acacia.

Legumes are preferred for revegetation of metal mine-mined waste land. A research on *Sesbania rostrata* and *S. cannabina* were potential for the reclamation of lead/zinc (Pb/Zn) mine tailings [17]. Another report shows that two leguminous shrubs (*Cytisus scoparius* and *Genista florida*) were adapted to 12 reclaimed mines in northern Spain [22].

The initial concept of land reclamation using one plant species has actually shifted to species community. The advantage of the second concept is that the structure of plant stands is more varied and can reach a more stable final structure [5,23,24]. The diversity and abundance of species will also be higher. The strategy for selecting reclamation plants in the future should be more adopting this concept.

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References

[1] Sari D P and Buchori I 2015 *J. Pembang. Wil. Kota* **11** 299–312
[2] Nugroho AW and Ishak Yassir 2017 *J. Anal. Kebijak. Kehutan* **14** 121–36
[3] Kloppers H and Du Plessis W 2008 *J. Energy Nat. Resour. Law* **26** 91–119
[4] Setyawan D, Gilkes R and Tongway D 2011 *J. Trop. Soils* **16** 219–23
[5] Armstrong K and Nichols O 2000 *For. Ecol. Manage.* **126** 213–25
[6] Erener A 2011 *Int. J. Coal Geol.* **86** 20–6
[7] Lan CY, Shu WS and Wong MH 1998 *Bioresour. Technol.* **65** 117–24
[8] Schmeisky H and Podlacha G 2005 *Landsc. Urban Plan.* **51** 159–63
[9] Valiantzas J D 2010 *J. Hydrol.* **384** 1–13
[10] Thomson J R, Moilanen AJ, Vesk PA, Bennett AF and Mac Nally R 2009 *Ecol Appl.* **19** 817–25
[11] Kozlowski T T 2002 *For. Ecol. Manage.* **158** 195–221
[12] Riley L E, Steinfeld D E, Winn L A and Lucas S L 2015 *Nat. Areas J.* **35** 45–53
[13] Tordoff G M, Baker A J M and Willis AJ 2000 *Chemosphere* **41** 219–28
[14] Smiles D E and Knight J H 1976 *Aust J Soil Res.* **14** 103-8
[15] Mollerup M 2007 *J. Hydrol.* **347** 173–6
[16] Tongway D J 2010 *Ecol. Restor.* **28** 182–7
[17] Ye Z H, Yang Z Y, Chan G Y S and Wong M H 2001 *Environ. Int.* **26** 449–55
[18] Keeling S M and Werren G 2005 *Remediation* **15** 53–61
[19] Bristow M, Vanclay JK, Brooks L and Hunt M 2006 *For. Ecol. Manage.* **233** 285–94
[20] Passell H D 2000 *Restor Ecol* **8** 112–8
[21] Turvey N D 1996 *For. Ecol. Manage.* **82** 185–95
[22] Alday J G, Santana V M, Marrs R H and Martínez-Ruiz C 2014 *Ecol. Eng.* **73** 691–8
[23] Maginel C J, Knapp B O, Kabrick J M, Olson E K and Muzika R-M 2016 *Ecol Indic.* **67** 58–67
[24] Sheoran V, Sheoran AS and Poonia P 2010 *Int. J. Soil, Sediment Water* **3** 1–21

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