Kampoeng Reklamasi: a case study of the designation reclamation type of an ex-tin mine in Bangka Island, Indonesia

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Abstract. Air Jangkang mine is one of tin mines operated by PT TimahTbk in Bangka Island. Decades of mining operation produced piles of tailing which mainly composed of silica sand. The soil samples taken from the area indicate acidic soil, poor organic content, and low values of cation changing capacity in addition to low levels of phosphor and potassium. The low pH value also plays pivotal roles regarding the leaching and mobilization of heavy metals that accumulated in the water and soil. This study explains how the planning and implementation of other designation reclamation type as specified in the regulation. The critical stage in this reclamation area is the recovery and enrichment of nutrient-deficient soil so that the nutrients are available for plant uptake. In terms of food safety from the reclamation area, PT TimahTbk gives serious attention through implementing series of toxicity tests on crops and fish. The result illustrates that the toxic metal concentration in the vegetables, fruit, and fish are vary with the highest concentration of Pb and As are found in the vegetables. Samples taken from radish and spinach show Pb concentration at 6.1 ppm and 2.01 ppm respectively, exceeding Indonesian national standard at 0.5. This result suggests that heavy metals are mainly accumulated in the roots of a plant.

1. Introduction
Mine closure is defined as systematic and continuous activities to restore the function of environment and social capacity according to the local condition after a part of the entire mining operation has ended[1],[2]. Therefore, the program comprises of reclamation activities and socio-economic development for the communities which had been affected by mining operation. According to Minister of Energy and Mineral Resources Decree No. 1827K/30/MEM/2018, reclamation of a former mining area can be conducted in the forms of revegetation or other designation which comprises of residential area, tourism, water sources, or cultivation area.

PT TimahTbk as one of the largest tin mining companies in Indonesia began conducting systematic research for revegetation of the tin mine since 1982 by collaborating with the Research and Development Agency of the Ministry of Agriculture. Furthermore, revegetation was carried out using Acacia plants (Acacia mangium and Acacia auriculiformis), gamal (Gliricidia sepium) and sengon (Albizia chinensis). Various efforts have been made to utilize ex-mining lands since then. Planting with horticulture and food crops has succeeded, however the progress was hampered by illegal miner activities[3][4].

Air Jangkang is a former tin mine located on Riding Panjang Village, Bangka Island, Indonesia (Figure 1). The region has been known as the main tin producer in the world with the tin mining...
activities recorded since the early eighteen century [5]. Integrated reclamation concept on a former tin mine in Air Jangkang which known as “Kampoeng Reklamasi” is a model of mine closure that combines eco-tourism development and agriculture with the main purpose as the tourist destination in the region. Kampoeng Reklamasi extends on 31 ha area which consists of pit lakes which locally known as “kolong” and sandy materials that formed by tailing accumulation.

![Figure 1. The location of Air Jangkang](image)

Kampoeng Reklamasi Air Jangkang as an eco-tourism area is one of mine closure programs conducted by PT Timah Tbk with the main objective to restore the land after tin production ceased. In order to optimally functionalize the area, it is developed by providing facilities and services for recreational activities in Riding Panjang Village.

2. Method
This study was conducted at Air Jangkang, Riding Panjang Village, Bangka Island. Soil, plants, and fish samples were collected by PT Timah Tbk and sent to Indonesian Center for Biodiversity and Biotechnology (ICBB) for further analysis. Soil characterisation was performed in order to measure the organic, nitrogen, phosphor, and potassium content of the soil and also its cation changing capacity, moisture, pH, and sand fraction. This method is used to understand the fertility of the soil in the area. Samples from radish, spinach, and mango were taken as the representation of the plants in Air Jangkang. In addition, catfish and silver catfish that live in the kolong also sampled to measure the heavy metal accumulation in each species as the basis for the fish cultivation program in the area.

3. Result and Discussion
The mining activities, especially surface mining, will cause disturbances to the vegetation on the mined location and the migration of the fauna. This process will eliminate the functions of the vegetated area, such as providing various forest products, habitat for the animals, source of food, and water sources [3] and [5]. In a surface tin mining operation, topsoil is stripped and ideally stored on topsoil storage and returned to the land when tin mining activities are completed or the reclamation will be carried out.
However, due to illegal miners activities in Air Jangkang which mined the reclaimed area, the original topsoil was washed out and sand tailing that mainly composed of silica is left as waste[5]. The loss of topsoil also means the loss of organic matter that is essential to maintain the quality of the land.

The results of soil analysis from Air Jangkang soil sample showed low C-organic content at 0.13%. Total nitrogen content also shows a low number of 0.02% (Table 1). It has low content of phosphorus, potassium and cation changing capacity which partly caused by high proportion of sand fraction and indicated that cations or nutrients needed by plants are easily washed away. The soil pH value at 4.92 also triggersthe leaching and mobilization process of metal in the soil.

**Table 1. The results of soil analysis from Air Jangkang**

| Parameter          | Unit      | Air Jangkang |
|--------------------|-----------|--------------|
| C-organic          | %         | 0.13         |
| N-Total            | %         | 0.02         |
| C/N Ratio          |           | 7            |
| P₂O₅ Available     | ppm       | 2.45         |
| P₂O₅ Potential     | mg/100mg  | 0.95         |
| K₂O Potential      | mg/100mg  | 2.73         |
| Cation Changing Capacity | cmol (+)/kg | 10.57 |
| pH                 |           | 4.92         |
| Moisture           | %         | 0.86         |
| Sand Fraction      | %         | 27           |
| Dust Fraction      | %         | 14           |
| Clay Fraction      | %         | 59           |

Considering the quality of soil in Air Jangkang which caused obstacles for reclamation in the form of revegetation, other designation types of reclamation in the form of eco-tourism is selected with the consideration of providing environmental and socio-economic benefits for the region[3]. The principles of developing eco-tourism are conservation, education, community participation, economy and recreation. Management of eco-tourism includes the following:

a. Area management includes the preparation and security of the area.

b. Management of eco-tourism products includes product development, product marketing, and product information systems.

c. Visitor management includes distribution strategy of the visitor, information for visitors, and visitor safety in order to anticipate and reduce the negative impact of visitor to the environment.

d. Institutional management includes organization, human resources, facilities and infrastructures.

The support of the surrounding community is vital for the sustainability of the program. Therefore, it is fundamental for the management to pay attention to the cultural values of the community in order to execute the eco-tourism project. The positive and negative impacts of the project should be considered in the feasibility study. In order to achieve the synergy between the company and the community, the development of Kampoeng Reklamasi Air Jangkang is based on stakeholders/consultation conducted by PT Timah as part of its mine closure program. Therefore, the surrounding communities will involve in the planning and operation of Air Jangkang[3] and [6].

Kampoeng Reklamasi Air Jangkang comprises of three main clusters (Figure 2). The first cluster is the plant zone where the indigenous Pelawan tree, fruits, and vegetables grow (Figure 3). The second cluster is used for cow farming and nursery while the third cluster reserved for fauna conservation and research facilities. In addition, “kolong” (pit lakes) were utilized as waterpark and aquaculture[6].
Heavy metals concentration (As, Pb, Cd, Hg) in the catfish from the area shows their metal contents below 0.009 ppm which far below the threshold value for heavy metal content in the fish products (Table 2). Therefore the fish from Air Jangkang is suitable for consumption. In contrast, the samples from the vegetables demonstrate high lead content as shown in Table 3 below.

The heavy metal concentration analysis results indicate that radish and spinach from Air Jangkang have a high Pb content at 6.1 ppm and 2.01 ppm respectively. It is exceeding the Indonesian National Standard for lead content in the food at 0.5 ppm. The high Pb content correlated with the characteristics of vegetables which have high absorption rate of heavy metals from the soil. Otherwise, mango fruit shows that its heavy metal content is below the standard. According to [7] and [8] Cd and As are relatively mobile in the soil-plants uptake system whilst the Pb is immobile. In addition, the leaching of metals in the soil also assisted by the acidic environment of the area. However, this data only sourced from one sample for each plant and further studies are needed to understand the distribution of heavy metal from the area.

![Figure 2. Three main clusters of Kampoeng Reklamasi Air Jangkang](image1)

![Figure 3. One of the clusters of Kampoeng Reklamasi Air Jangkang (the plant zone)](image2)

**Table 2. The results of heavy metals analysis in fish**

| Parameter | Unit | Catfish | Silver Catfish |
|-----------|------|---------|---------------|
| C-organic | %    | 74.61   | 78.40         |
| Arsenic   | Ppm  | < 0.008 | < 0.008       |
| Mercury   | Ppm  | < 0.004 | < 0.004       |
| Lead      | Ppm  | < 0.009 | < 0.009       |
| Cadmium   | Ppm  | < 0.00011 | < 0.00011   |
Table 3. The results of heavy metal analysis in plants

| Parameter  | Unit | Radish | Spinach | Mango |
|------------|------|--------|---------|-------|
| C-organic  | %    | 44.96  | 43.99   | 54.55 |
| Moisture   | %    | 1.71   | 0.72    | 3.89  |
| Arsenic    | ppm  | < 0.01 | < 0.01  | < 0.01|
| Mercury    | ppm  | < 0.01 | < 0.01  | < 0.01|
| Lead       | ppm  | 6.1    | 2.01    | < 0.08|
| Cadmium    | ppm  | < 0.01 | < 0.01  | < 0.01|
| Lanthanum  | ppm  | < 0.1  | < 0.1   | < 0.1 |
| Cerium     | ppm  | < 0.3  | < 0.3   | < 0.3 |
| Cyanide    | ppm  | 3.76   | 9.24    | 0.81  |

4. Conclusion
The results of soil analysis from Kampoeng Reklamasi Air Jangkang indicated low organic matters in the soil, therefore the strategy to develop the location as an eco-tourism area was chosen. Kampoeng Reklamasi Air Jangkang comprises three main clusters which are plants zone, cow farming and nursery, and also fauna conservation area. Vegetables and fruit plants were planted in the plants zone of Air. However, the heavy metals concentration in vegetables shows high content of Pb in radish and spinach.

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References
[1] world bank, wealth and Sustainability: The Environmental and sosial Dimensions of the Mining Sector in Peru, 2005.
[2] Mine Closure and Completion, 2006.
[3] PT Timah Tbk, "Rencana Reklamasi PT.Timah Tbk Periode Tahun 2019-2024," PT Timah Tbk, Bangka Belitung, 2019.
[4] C Agus, D Wulandari, E Primananda, A Hendryan, and V Harianja, "The Role of Soil Amendment on Tropical Post Tin Mining Area in Bangka Island Indonesia for Dignified and Sustainable Environment and Life," in 2nd International Conference on Green Energy Technology (ICGET 2017), Rome, Italy, 2017.
[5] H F Putra and N S Aryanti, "Landscape Function of Post Tin-Mining Land After Reclamation in Bangka, Indonesia," in 2nd International Conference on Green Energy Technology (ICGET 2017) - Ei Compendex, SCOPUS, Rome, Italy, 2017.
[6] PT.Timah Tbk, Rencana Pascatambang PT Timah Tbk, 2019.
[7] Wolfgang Calmano, Jihua Hong, and Ulrich Forstner, "Binding ang Mobilization of Heavy Metals in Contaminated Sediments affected by PH and redox Potential," in The First International Specialized Conference, Hamburg, 1993.
[8] Mashael M Alsihany, Adel M Ghoneim, and Najat A Bukhari, "Transfer and Accumulation of Some Heavy Metals in Native Vegetation Plants," International journal of Plant & Soil Science, vol. XXVIII, no. 4, pp. 1-10, June 2019.