Analysis of Heavy Metal and Clay Mineral in Heath Forest and Post Tin Mined Land on Belitung Island, Indonesia

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Introduction

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Duration of study : 6 Months
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Topic of Master Thesis:
“Ecology Restoration in Damaged Heath Forest which caused by Tin Mining Activity”
Background

- Lost of biodiversity and damaged of soil
- Heavy metal contamination as a potential soil pollutant.
- Effects of heavy metals on plants result in growth inhibition.
- Clay fraction has high potential to bind heavy metals
- Type of clay minerals is one of factor which determine the soil’s ability to retain and immobilize heavy metals

Objectives

Study in IPB
- To understand soil properties
- To understand vegetation composition
- To develop recommendation for ecosystem restoration

Study in Kyoto University
1. To clarify heavy metal potential
2. To identify clay mineral composition

Study Site

Location: East Belitung District, Bangka Belitung Province, Indonesia
Heavy Metal

• Extraction Method

BCR three step sequential extraction procedure (Rauret et al. 1999)

<table>
<thead>
<tr>
<th>Step</th>
<th>Fraction</th>
<th>Target</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Exchangeable, water and acid soluble</td>
<td>Soluble species, carbonates, cation exchange site</td>
<td>Acetic Acid 0.11 M</td>
</tr>
<tr>
<td>S2</td>
<td>Reducible</td>
<td>Iron and manganese oxyhydroxide</td>
<td>Hydroxylammonium Chloride 0.5 M</td>
</tr>
<tr>
<td>S3</td>
<td>Oxidisable</td>
<td>Organic matter and sulphide</td>
<td>Hydrogen Peroxyde 8.8 M followed by Ammonium Acetate 1 M</td>
</tr>
</tbody>
</table>

The metal content was measured by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)

Clay Mineral

• Method

X-Ray Diffraction Techniques

- Silicate mineral is the most dominant mineral as a rock formed and found in the soil.
- Primary silicate mineral: Quartz (poor nutrient), Feldspar (rich nutrient)
- Secondary silicate mineral: kaolinite (1:1), vermiculite, illite (2:1)
- Secondary non-silicate mineral: gibbsite
Results of Heavy Metal Analysis

The Highest Concentration Among All Fraction of Heavy Metal in Forest and Post Tin Mined Land

<table>
<thead>
<tr>
<th>Concentration of Heavy metal [mg/kg]</th>
<th>Forest</th>
<th>PML &gt; 100 (sandy)</th>
<th>PML &gt; 100 (forest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium (Cd)</td>
<td>Non reliable</td>
<td>Non reliable</td>
<td>Non reliable</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>3,615 (S3)*</td>
<td>0,1 (S1)</td>
<td>0,02 (S1)</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>2,728 (S2)</td>
<td>2,524 (S2)</td>
<td>1,425 (S2)</td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>0,372 (S1)</td>
<td>0,76 (S1)</td>
<td>0,428 (S1)</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>Non reliable</td>
<td>Non reliable</td>
<td>Non reliable</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>1,616 (S1)</td>
<td>0,175 (S3)</td>
<td>0,46 (S1)</td>
</tr>
</tbody>
</table>

* : Detected

All concentrations of heavy metal are below the threshold of ecology risk (Ecological Investigation Level, Department of Environment and Conservation, Australia (2010)).

Source of heavy metal

- Cu is a mobile element and adequate high concentration than other elements.
- Undetected Cu in fraction 3 is supposed by completely leached in step 1 and 2. Then, remained the minor mineral which contain Cr and Ni can be detected in sulphide.
- Cr, Cu, Ni, relatively decreased, after natural succession.
- ZnS is supposed as the main sulphide mineral followed by PbS. Thus, Zn can be detected in all fractions.
Qualitative correlation with other soil properties

<table>
<thead>
<tr>
<th>Properties</th>
<th>EPSC (Forest)</th>
<th>PML &gt; 100 ys (sandy)</th>
<th>PML &gt; 100 ys (small forest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand [%]</td>
<td>52,94</td>
<td>96,96</td>
<td>70,85</td>
</tr>
<tr>
<td>Silt [%]</td>
<td>10,19</td>
<td>1,32</td>
<td>17,8</td>
</tr>
<tr>
<td>Clay [%]</td>
<td>36,87</td>
<td>1,72</td>
<td>11,35</td>
</tr>
<tr>
<td>pH</td>
<td>4,7</td>
<td>6,0</td>
<td>4,5</td>
</tr>
<tr>
<td>C-org [%]</td>
<td>2,00</td>
<td>0,08</td>
<td>1,17</td>
</tr>
<tr>
<td>N [%]</td>
<td>0,19</td>
<td>0,04</td>
<td>0,12</td>
</tr>
<tr>
<td>CEC [me/100g]</td>
<td>5,83</td>
<td>0,60</td>
<td>6,04</td>
</tr>
<tr>
<td>Ca [me/100g]</td>
<td>0,52</td>
<td>0,27</td>
<td>0,41</td>
</tr>
<tr>
<td>Mg [me/100g]</td>
<td>0,24</td>
<td>0,05</td>
<td>0,16</td>
</tr>
</tbody>
</table>

- Cr in forest is more potential than open area, due to pH more acidic than post tin mined land.
- The highest concentration of Cr, Cu, Zn is in the forest.
- The spatial distribution of Cu and Zn correlated to the soil organic matter distribution.
- There were indications that the immobile fraction of the heavy metals was adsorbed onto Mn-oxides (Aydinalp et al. 2003).

Results of Clay Mineral Analysis

Clay Mineral Composition in forest and post tin mined land

<table>
<thead>
<tr>
<th>Clay mineral</th>
<th>Forest</th>
<th>PML &gt; 100 (sandy)</th>
<th>PML &gt; 100 (forest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>-</td>
<td>±</td>
<td>+</td>
</tr>
<tr>
<td>Orthoclasis</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>±</td>
<td>+</td>
</tr>
<tr>
<td>Vermiculite</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Illite</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Kaolinite</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Gibbsite</td>
<td>+</td>
<td>+</td>
<td>±</td>
</tr>
</tbody>
</table>

- Dominant of kaolinite indicated the low of Cation exchange capacity.
- Found quartz is supposed by mining activity which digging the inside soil to the surface and indicated poor of nutrient.
- Thus impact to sandy soil in that area, which need long time to recover the soil texture.
Vegetation Composition

- Number of species and individual relatively decreased from forest ecosystem to PML < 100 years and PML > 100 years except for herbs, shrubs, liana species.
- Succession phase is still going on in post tin mined land. Thus, found some herbs, shrubs and some liana are pioneer species there.
- Presence of vegetation could influence the soil development process in soil organic matter availability.

Growth performance of some species

- *Rhodomyrtus tomentosa* grow as shrubs and produced sufficient litters
- Stunted *Callophyllum lanigerum* which grow and produced fruit (generative phase)
- Root of *Malaleuca leucadenron* grow on the soil surface
- High density of saplings and small tree (thin), as a characteristic of heath forest ecosystem
Conclusion

✓ Heavy metal concentration in all locations are low and below the standard of Ecological Investigation Level. Thus, it is not necessary to conduct bio-remediation or phyto-remediation.
✓ Some heavy metals were detected in forest ecosystem in high concentration, it means that forest has a function to keep some elements and minerals.
✓ Heavy metal can be non essential nutrient for plant.
✓ For soils with low clay contents and/or low cation exchange capacity, application of organic fertilizer maybe an effective option to improve or maintain nutrient levels by providing nutrients and organic colloids.

GSGES Experiences

Wakayama Field Trip (21-22 June 2014)

✓ Wakayama area has high potential to be developed as Agrotourism Area (from forest, slope plantation area, lowland and coastal area).

Visit Satoyama in Otsu and Kamigamo Experimental Station (26-27 July 2014)

✓ Kamigamo Experimental Station is invaded by fern which cover the forest floor. It is hindering the natural regeneration.
Lesson Learned during Study in Kyoto University

- My study in Kyoto U is very useful for my research in Indonesia, data and information about Heavy Metal and Clay Mineral will support my data to understand about soil condition in forest and post tin mined land in Belitung comprehensively.
- By learning soil properties (chemical, physical, biology), vegetation composition, geology and mineralogy history, I try to understand about ecology process.

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THANK YOU VERY MUCH 😊