The Ability of Plants to Accumulate Aurum (Au) in the Central Kapuas Gold Mining Region

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Abstract
The purpose of this study is to (1) inventory and identify a number of plant species that can be used as indicators of the presence of gold. (2) Analyze the content of Au in plant specimens which are suspected as a pointer in the gold mining region. (3) Study the transport mechanism of Au in plants. The research activity consists of two stages. Stage I is identifying the plants species in the gold mining region which is believed to locals as an indicator of the presence of gold. Stage II is gathering scientific evidence through laboratory analysis, and verified by the knowledge society. The inventory and identification results in the finding of 11 species of plants that are believed by the gold miners as indicators of the presence of gold, which are Tristania merguensis (Griff.), Melaleuca soulatrii Lin., Syzygium syvlicum (L) DC., Dillenia excelsa Gilg., Shorea maxwelliana King., Calophyllum hoseri Ridl., Dipteroncarpus octovalus King., Agrostistachys sessilifolia (Kurz) Pax & Hoffm., Gluta ranguas L., Combretocarpus soulatii Roxb., and Memecylon myrsinoides. Blume. Based on the results of a calculation with a quantitative approach, the value of the interests of the species (Fidelity level) shows that Kantue (A. sessilifolia (Kurz) Pax & Hoffm) has the highest FL value of interest (48.48%). Similarly, the value (Use Value) for Kantue (A. sessilifolia (Kurz) Pax & Hoffm) is higher than the others. The laboratory analysis of the 11 species of plants show that they can accumulate the Au in roots stems and leaves tissue in varying levels. The highest average value is found in the stems of 130.36 ppb, in leaves 85.45 ppb, and the lowest is on the roots of 64.72 ppb. The correlation analysis also shows that the accumulation of Au in plants has correlation with the presence of Au in the soil. This indicates that the plants are able to take and transport Au from the soil through the roots then being accumulated in the stem and leaves.

Keywords: Ability of plants, accumulation of Au, gold mining

Introduction
Indonesia has a tropical forest with a numerous kinds of flora and a complex vegetation structure. Diverse plant species in the forest than used as medicinal plants, they also has a practical potential as an indicator of a particular environment. In relation to biodiversity in Indonesia, the usage of plants growing in all intents and purposes, particularly on behalf of the meaning of culture, and also economic value. The traditional behavior that had already been entrenched in the cultural life of the community needs to be utilized. Ethnic identity is formed by perceptions of historical and cultural experiences that are both traditional and modern [1].

The potential for gold deposits found in almost every region of Indonesia. In the Central Kapuas, Central Kalimantan has vast forests and there are many different types of plants used by local people (indigenous knowledge). There are some residents who use certain types of plants as markers (indicators) to find specific places that expected to contain gold. There are several types of forest plants that are believed by the Dayak tribe in Central Kalimantan as plant indicators of a metallic gold (Au). However, there has not been any scientific truth yet about why the plant is used as a marker.

Based on information and interviews with local gold miners in the gold mining area of the Central Kapuas, Central Kalimantan, there are certain types of plants that are used as indicators of gold (Au). The gold miners are generally believed that when an indicator plant found, then they estimate there is gold element in the surrounding area. Gold mining areas are laid in forests where the certain types of plants that are used as indicators are found.

Plants that accumulate metals in their above ground tissues are termed metal non-excluder. They could be divided to indicators and hyperaccumulators. Indicators species should have levels of metals in their tissues reflected to their levels in soil [2]. Girling and Peterson [3] reported that some plant species can accumulate gold element in the body tissues. This element can be present in plants in concentrations that vary, depending on the type, growth rate, and soil factors in the environment. Concentration of gold...
elements in plants taken from different areas, absorption is very small (in ppb) of between 10-200 ppb (dry weight). Further observations indicate the presence of gold metal section at the roots and stems of seven plant species studied. The existence of an element in the plant body is very possible including metallic gold (Aurum), because basically all of the elements are present in the plant body even though the amount is very small [4].

Gold metal are transported in plants is depends on the metabolic processes of a nutrient solution containing gold and pH influence the growth medium. Gold element storage location is not the same for every plant. There are some species accumulate the gold in the bud, specifically for (H. vulgare and P. tanaceti), but most of the experimental results in a soluble form found in the roots and the stem for the insoluble form. The study to trace the process of capture, transport, localization, and distribution of gold in plants shows that the presence of gold in plants plays a complex role, but it is significantly taking an important part in the formation of the gold cycle. The results Reith et al. [3] in the gold mines Tomakin, showed that the leaves and rubbish that grows in a layer of gold mineralization of soil is containing high concentrations of Au.

Based on the idea of the ability of plants to absorb ions with a specific transport mechanism resulting in the accumulation of metallic minerals in the body of plant, then the ecological implications need to be known if the plants are expected to be an indicator of Au also has the ability to absorb and accumulate gold metal. What about the other plant species, do they also have the ability to bind metallic Au? It certainly needs to be studied further.

Materials and Methods

Study area and collection of plant and soil samples

The plants and soil samples used for this research were collected in 2010 from the surrounding area of the central Kapuas, at Central Kalimantan. Plants and soil samples were collected randomly from 3 different locations, where plants were obtained from informants in the gold mining areas later identified. Soil samples were taken from surrounding the plant indicator, the depths of soil samples were 15-30 cm. To identify the plants that were found in gold mining, the author used descriptive qualitative approach by describing plant specimens and matched with a book/literature or other documents. Identification of plant performed in the Laboratory of Biology, Palangkaraya University, if there could not be identified it will be sent to Herbarium-Bogoriense.

Analysis of Au content in plants

The next step Au content analysis used a quantitative approach, plant samples were analyzed for Au levels in the laboratory. The parts of plant organ sample to be analyzed are roots, stems and leaves, and to be selected at random sampling. Analysis of the content of Au using Atomic Absorption Spectroscopy (AAS) was observed at a 242.8 nm wavelength.

Results and Discussion

The result of interview with local people who use plants as an indicator of the presence of gold in the Central Kapuas, there are 11 plants species that are believed by Dayak Ngaju tribe as plant indicators that show the presence of gold, in specific habitat. The types of plants that are informed by local people as gold plants indicator and habitats found in (Table 1).

A review of ethno botany of the 11 plant species in the informant's experience of each type of plant to characterize the content of gold in the ground is different. Thus, to prove the local people’s statement, the study also analyzed the levels of Au in soil as a medium growth in laboratory analysis. The result of the analysis shows that the plants have ability to absorb metals Au in varying level of Au in plant. Plants are tolerant of the environment and be able to accumulate metals in tissues roots, stems and leaves. The difference in levels of Au in the roots, stems and leaves are used as plants indicator can be seen in (Figure 1).
Table 1. The types of indicators Au plants

<table>
<thead>
<tr>
<th>No</th>
<th>Local names</th>
<th>Scientific names</th>
<th>Famil</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kapur naga</td>
<td>Calophyllum hosei Ridl</td>
<td>Clusiaceae</td>
<td>Peat soils</td>
</tr>
<tr>
<td>2</td>
<td>Katumbu</td>
<td>Dillenia excelsa Gilg</td>
<td>Dilleniaceae</td>
<td>Hill, with the sandy soil characteristics</td>
</tr>
<tr>
<td>3</td>
<td>Karuing</td>
<td>Dipterocarpus crinitus Dyer</td>
<td>Dipterocarpaceae</td>
<td>Heath forest, sandy peat soil</td>
</tr>
<tr>
<td>4</td>
<td>Katune</td>
<td>Agrostistachys sessifolia (Kurz)</td>
<td>Euphorbiaceae</td>
<td>Hills, sandy peat soil</td>
</tr>
<tr>
<td>5</td>
<td>Pelawan</td>
<td>Tristania merguensis (Griff)</td>
<td>Myrtaceae</td>
<td>Heath forest, sandy peat soil</td>
</tr>
<tr>
<td>6</td>
<td>Galam tikus</td>
<td>Melaleuca soulatri L.</td>
<td>Myrtaceae</td>
<td>Heath forest, sandy peat soil</td>
</tr>
<tr>
<td>7</td>
<td>Katiau</td>
<td>Shorea maxweliana King</td>
<td>Dipterocarpaceae</td>
<td>Little watery peat soil</td>
</tr>
<tr>
<td>8</td>
<td>Rangas</td>
<td>Gluta renghas L.</td>
<td>Anacardiaceae</td>
<td>peat soil</td>
</tr>
<tr>
<td>9</td>
<td>Kayu lalas</td>
<td>Syzygium zealanicum (L.) DC</td>
<td>Myrtaceae</td>
<td>Hills, sandy soil</td>
</tr>
<tr>
<td>10</td>
<td>Tumih</td>
<td>Combretocarpus rotundatus Miq</td>
<td>Anisophylleaceae</td>
<td>sandy peat soil</td>
</tr>
<tr>
<td>11</td>
<td>Kayu emas</td>
<td>Memecylon myrsinoides Blume</td>
<td>Melastomataceae</td>
<td>sandy peat soil</td>
</tr>
</tbody>
</table>

Figure 1. Au levels in soil and plants

Location and Potential Accumulation of Au in Plant

Based on data analysis of Au content (Figure 1), it shows that the accumulation of Au in plants section contained in roots, stems and leaves. Those mean the highest accumulation levels of Au contained in the stems of 135.81 ppb, in the leaves 88.81 ppb, and the lowest in the root of 67.81 ppb. The data also shows that in places it is overgrown with plants, from the analysis of the growth media (soil) indicates the presence of high levels of Au in soil 483.81 ppb. Especially for the land as a place to grow Katune, informants expressed as a specific sign as indicator plants, have the highest level of Au soil than others.

Plants potentially take Au from the environment and accumulate them in the body tissues \cite{6}, it is because some species of plants from several families hyper tolerant shown to have properties, which are able to accumulate high concentrations of metals with a network of roots, stems and leaves that are hyper accumulator. Presented by Gupta \cite{4}, the existence of an element in the plant body is very possible including metallic gold (Au), because basically all of the elements present in plants, although the number is very small. Au accumulation in plant tissue (woody) on a couple of types of plants have been reported by Jones \cite{3} are usually in the range of ppb/dry weight. This is in line with the results of the study, from a few samples analyzed Au apparently accumulated in roots, stems and leaves are also in the ppb range.

The result of the analysis showed the accumulation level of Au in the stem and it is higher than elsewhere, probably because gold compounds in dissolved form is transported from the roots to get to the next stem (in the stem) stored in the form insoluble. This can happen due to the metal transport
mechanisms that are Cellular exclusion (storage in the cell) in the apoplastic free space that forms a complex between the membrane and the cell wall. This is consistent with the results of Dunn [7] of 24 samples being ashes Alnus crispa, based on the results obtained by chemical analysis of various concentrations ranging from 5ppb - 14 ppb on the twig, 14 ppb in the leaves, and 140 ppb in the shaft (skin timber). The conclusion that can be drawn from the data analysis is that small amounts of ash Au can be maintained in the cells of twigs or leaves (Alnus crispa) and partly dissolved in the sap. According Padmavathiamma & Li [8] also stated that some hyper accumulator plants can absorb larger amounts of the compound compared to other plants. Hyper accumulator metals can accumulate in plants and concentrations are greater in the stem than in the non-accumulator plants that are usually found.

Plants are basically able to accumulate Au, but the author does not recommend this study for the extraction of gold (phytomining). Gold extraction by plants considered to be economically and environmentally damaging, in addition to the required cost although recently people have been searching for several plants that is hyper accumulator gold for economic interests. The ability of plants to accumulate gold used to phytomining the use of plants to accumulate precious metals from mining waste substrate (tailings) or mineral soil. This technique has been applied in areas where the concentration of the metal is not suitable for extracted using conventional technology [9,10,11].

Transport Mechanisms of Au in Plants

Au uptake and transport in the root zone transport against gravity from the roots to the leaves, and accumulation occurs in the leaves, bark, twigs, and finally to the trash / litter. Plants can be an important contributor to the mediation of the biological cycle of Au in soil regolith [5]. Plants take up some kind of metal from the environment, influenced by soil conditions such as pH, temperature and oxygen is an important factor in the transport of inorganic elements and organic compounds. In addition, some organic compounds play a role in the transport of metals form complexes with compounds in the soil and increase bioavailability and metal uptake [12]. Through this form of transporter molecules that have a low mass is actively secreted by plant roots and serves as chelators. Chelating mechanism, estimated metal element is absorbed in the form of metal-chelate complexes are synthesized Phytochelatin sulfhydryl of glutathione in plants [13].

The physiology of Au transport mechanism has not been studied, but basically it works the same way as the transport other metals. Plants accumulate metals from the soil solution. Before transporting of metals from the soil solution into the plant, the root surface must pass through passive transport mechanisms. Metal ions move through the pore walls of root cells through the crowd, or through a process of transporting symplastic through root cells. Absorption of Au from the soil solution to the root surface is possibilities in the oxidized form of ions and into the root cells. The complex nature of the rhizosphere is dynamic and constantly changing lead to variations in the metal collection. The next process proposed Prasad [14] that there is a specific membrane protein in plants to identify the chemical structure of essential metals, metal binding proteins and then be ready for absorption and transport. At the root of these elements are transported through the vascular system to the top (shoot). Different chelator can be involved in the translocation of metal cations through the xylem, such as organic acids (malic, citric acid, histidine). The metal is transported in the form of a chelate complex and translocated upward through the xylem.

Relationship between Accumulation of Au Potential and the Presence of Gold

Based on the results of the study indicate that plants are able to accumulate gold mining region of Au at the roots, stems and leaves. Furthermore, the result of correlation analysis between the roots, the stems, and the leaves soil showed a positive correlation. This means that there is a relationship between levels of Au in plants with elevated levels of Au in soil. In other words, it can be said there is a correlation with the levels of Au in plant and deposits in the soil. The presence of Au on the number of plant species are believed to be indicators of the presence of the gold, proving that local knowledge about plant communities’ markers can be proven scientifically. This is in line with that proposed by Root [15] the metal content in plants is believed to be a tool to estimate the deposit content in them, through the analysis of the content of Au in plants is one effective way to infer the presence of heavy metals in the soil.
Furthermore, it also stated the presence of metal in the leaves, stems or roots of certain plants indicate the content of deposits underneath. The results of the analysis of Au accumulation in plants showed the highest found in the stems, while the lowest levels found in the root, it is the possibility of the roots stored in dissolved form, in addition to transport Au strongly influenced soil pH, so the pH will directly influence its effect upon the roots [16]. While in the stems is not directly affected soil pH, other than that at the Au rods stored in insoluble form.

Conclusion

The results of identification there are 11 species of plants used as indicator to indicate the presence of gold. The laboratory analysis of 11 species of plants are found, it can accumulate Au in the roots tissue, stems and leaves with varying levels. Correlation analysis showed a significant correlation between high levels of Au in the roots, stems and leaves with Au content in the soils. This means that the presence of Au in plants has the potential presence of Au in soil.

Acknowledgments

Many thanks for Professor Dr. H. Yusuf Abdurrajak, Professor Dr. Agr. Mohamad Amin, M.Si and Bapak Luchman Hakim, SSi. M.AgrSc,.Ph.D as a promotor and co-promotor of my Dissertation. And also thanks to ICGRC-2013 which has facilitated for scientific publications. Without whom this work would not have been possible.

References


[14] Prasad, M. N. V. (2006), Plant-mineral nutrition: macro and micro nutrients, uptake, functions, deficiency and toxicity symptoms, Department of Plant Sciences School of Life Sciences University of Hyderabad, India.
