Color-ornamental Plants Cultivation for Metal Waste Reduction on Mining Sites and Their Biorecovery of Metals

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Abstract: Metals, Minerals and Rock as minerals, are important aspects in the economic and social development of a country. However, due to the lack of communication between the private sector as a miner and the government as a supervisory party, there has been a lot of illegal mining occurring and no effort to revise the environment so that it has an impact on people's welfare and environmental pollution that is increasingly high. So as to reduce the level of environmental pollution that is currently needed there is the processing of mining waste. The metal will form complex bonds of coordination with ligands and form compounds of a certain color. By knowing the nature of these plants, the selection of plants that have a tendency to bind metal ions can be complexly coordinated to reduce the waste of metal ions generated from mining processing activities or on mining sites.

Keywords: color ornamental plants; biorecovery; mining site; metal waste; waste reduction

1. Introduction

Metals, Minerals and Rock as minerals, are important aspects in the economic and social development of a country. The mining material is currently widely applied as a starting material in the manufacture of application materials such as electronic equipment, to jewelry. However, however, the existence of these mining items has limited the amount of resources available in a place [1]. Some problems that often occur today are illegal mining and weak government control in the continuation of mining activities. The local government also does not have a very good insight related to mining activities which actually gives a lot of adverse impacts on the environment, as well as the lack of weak utilization of mineral resources in certain areas. These mineral resources should be one of the sources of income from the economic sector to provide welfare to the community. However, due to the lack of communication between the private sector as a miner and the government as a supervisory party, there has been a lot of illegal mining occurring and no effort to revise the environment so that it has an impact on people's welfare and environmental pollution that is increasingly high. So as to reduce the level of environmental pollution that is currently needed there is the processing of mining waste.

2. Coordination Covalent Bonding between Metals and Color-ornamental Plants

The metal will form complex bonds of coordination with ligands and form compounds of a certain color. This also applies to plants that have large molecular weight ligands, for example in plants shown in **Figure 1**. Metal ions such as iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu), which in Mining sites often become waste, instead they play an important role for healthy plant growth, which is needed for the structural and catalytic role in proteins involved in metabolism and development. However, excess free metal ions are toxic to cells because the generation of reactive oxygen species or through the transfer of other metal ions from sites in

metalloproteins makes them function[2-4]. Therefore plants have a mechanism for metal homeostasis that allows the absorption and distribution of metals to tissues while keeping metals in cells or subcellular compartments below the level that causes toxic symptoms [2,4,5].

Fig. 1. Ornamental plants used in mining waste treatment and metal biorecovery, (a) *Lavandula luisieri* [23], (b) *Cistus ladanifer* [24], (c) *Carlina corymbosa* [25], (d) *Echium plantagineum* [26] , and (e) *Rumex induratus* [27], courtesy on Wikipedia; Mediterranean Botanical Garden Society; and Ideal Waste.

Ornamental plants, which have a certain color, have their own mechanism to bind metal ions to bind to their cells as ligands and form complex compounds. As explained in **Figure 2** and **Figure 3**, metal ions that enter the root will undergo transformation spread in all parts of plant cells, such as roots, stems, leaves, to flowers. The attachment also certainly has the strength of different molecules attraction, and of course produces different physical shapes such as color [2-8]. By knowing the nature of these plants, the selection of plants that have a tendency to bind metal ions can be complexly coordinated to reduce the waste of metal ions generated from mining processing activities or on mining sites. In the referenced research article, the selection of plants used to reduce the abundance of metal waste by using ornamental plants that aesthetically have a certain color dominance, and of course later will be discussed further for the attachment of a metal ion from the waste with ornamental plants that are made of metal-trap plants.

3. Methodology Review

Eighty-five plant samples were collected from different sampling locations from the mining area. For each type of plant, in this case the plants used include *Lavandula luisierra*, *Erica australis*, *Rumex induratus*, *Corrigiola telephypholia*, *Agrostis castellana*, *Eritrae pulcheria*, *Daphne gnidium*, *Carlina corymbosa*, *Cistus ladanifer*, *Corrigiola telephypholia*, *Agrostis castellana*, *Eritrae pulcheria*, *Daphne gnidium*, *Carlina corymbosa*, *Cistus ladanifer*, *Corrigiola telephypholia*, *Agrostis castellana*, *Eritrea* and *Genista hirsutus*, five plant samples were collected from one sampling location and mixed together. The roots, stems, leaves and flowers of these plant species are separated. The roots are washed with water and rinsed with HCl solution followed by several rinses with DO water. The shoots (stems, leaves, and flowers) of plant species are washed with water followed by several rinses with DO water to remove all particulate matter attached to the stems, leaves, and flowers (buds). The cleaned and washed plant material is carried out, ground in a ball mill until homogeneous, and made into pellets for neutron activation analysis, following the standard procedure. Subsequently the sample was analyzed for mineralogy and chemical elements [22].

Fig. 2. Localization and distribution of metal ions in stem cells, according to the references [2-3,5-6,8-11,14-16,19-21]

Fig. 3. Localization and distribution of metal ions in plant cells and forming complex bonds, adapted from the references [2,4-6,9-13,16-18].

4. Discussion

From the results of the analysis shown in **table 1**, a list of the metal elements captured in significant amounts and greatly reducing pollution is indicated by columns As, Cr, Fe, and Zn. From the results of the planting, Cd metal is not much attached to ornamental plants grown in any mining site area. However, one of the most toxic metals absorbed in plants is the As metal, which is significantly absorbed by plant species *Erica andavalensis* and *Erica australis* and found in the flower section. The accumulation of other recorded metal wastes, Sb, is almost similar to the As metal absorption trend, which is highest in plant species *Erica andavalensis* and *Erica australis* and found in the flower section.

Table 1. Concentrations of absorbed metals in the plant species section [22], quoted from Springer-verlag (2011).

Plants Species (Plant's parts)	Concentration Range of Trace Elements (ppm)							
	As	Co	Cr	Cs	Fe	Sb	Se	Zn
<i>Lavandula luisierra</i> (leaves)	5-10		10-15	<0.01	500-700	1-2	3-5	300-400
<i>Erica australis</i> (Leaves)	25-30	<1	8-10		1,000-1,200	3-5	<1	37-42
<i>Rumex induratus</i> (Stem)	<5		8-10		300-400	<1	10-14	33-35
<i>Corrigiola telephypholia</i> (Leaves)	10-20	1-2	5-8		800-1,000	3-4	1-3	220-250
<i>Agrostis castellana</i> (Upper Roots)	5-10	<1	3-5		250-350	~1		25-30
<i>Eritrae pulcheria</i> (Upper roots)	10-15		5-8		500-700	1-3	4-6	37-42
<i>Daphne gnidium</i> (Leaves)	<5		8-10		250	<1	15-20	90-110
<i>Carlina corymbosa</i> (Leaves)		<1	10-12		500-700	1-2	5-10	~40
<i>Cistus ladanifer</i> (Leaves)		2-3	8-10		250-350	<1	13-15	100-200
<i>Erica australis</i> (Leaves)		1-2	5-10		400-500	1-2	<1	70-90
<i>Ulex eriocladus</i> (Upper roots)	5-10	<1	8-10	<1	300-400	<1	3-5	30-40
<i>Lavandula luisierra</i> (Leaves)					250-350		~5	90-110
<i>Echium plantagium</i> (Leaves)		<1	10-15	0.12	400-500	2-3	3-5	70-90
<i>Gramina</i> (Upper roots)			10-13	<0.1	300-400	1-2	1-3	40-60
<i>Erica australis</i> (Flowers)		3-5	5-10	<0.2	800-1,000	2-4	<0.5	300-400
<i>Erica andevalensis</i> (Flowers)	40-50	2-3	8-10	1-2	1,000-1,200	5-7	<1	200-300
<i>Genista hirsutus</i> (Upper roots)	5-10	<1		<0.1	300-400	<1	<0.5	33-35

When viewed as a whole, plant species *Erica andavalensis* and *Erica australis* are plants that absorb the most metal waste (Fe, As, Cr, Cs, Zn, and Sb) from the mining site, although for Se it is lower. When viewed from the physical appearance and growth, this plant species is a plant that has thick purple flowers, so it is not surprising that a lot of metal content is bound to many parts of the plant [2,5,7]. When viewed more closely related to its growth, this plant is a plant that is very tolerant to be grown or cultivated anywhere, so this plant is very applicable to be used as metal-trap plants at the mine site which is being hit by a waste treatment [7,11,16-15]. This plant also has a high level of photostability compared to the others, so that when it absorbs a lot of metal waste it does not cause damage to the plant [2,5,16-19]. However, these conditions will actually further emphasize the color of the flowers of these *Erica* species plants so that they can also increase the power and selling prices of these plants [22]. Therefore, tracing back the results of research conducted and the potential of plant species *Erica andavalensis* and *Erica australis*, it can be concluded that these plants can be cultivated in Indonesia to reduce mining waste, protect the environment from pollution, and increase plant competitiveness in the field of cultivation, so that mining metal biorecovery will not be wasted and can be utilized and further processed to be applied in the industrial field, especially the electronic material industry or heavy equipment.

5. Conclusions

Based on the objective, it can be concluded that ornamental plants have their own mechanism to bind metal ions to bind to their cells as ligands and form complex compounds, as identified physically by its certain color. The selection of plants that have a tendency to bind metal ions can be complexly coordinated to reduce the waste of metal ions generated from mining processing activities or on mining sites. When viewed from the physical appearance and growth, ornament plant species have several colors; therefore it is not surprising that a lot of metal content is bound to many parts of the plant. If viewed more closely related to its growth, these ornamental plants is highly adaptable to be grown or cultivated anywhere, so this plant is very applicable to be used as metal-trap plants for mining waste treatment. On forward, it is potentially prospective for mining waste reduction and environment protection from pollution.

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