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Preliminary Test of Mining Wastewater Containing Iron (III) and Aluminium (III) on *Lepironia articulata* in Phytoremediation

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ABSTRACT

Preliminary test was conducted to physically observe and determine the range of ferric [Fe (III)] and aluminium [Al (III)] concentrations that the *Lepironia articulata* can grow and survive. Pails of 3 L containing 3 kg of sand, and 42 days old *L. articulata* were exposed to different concentrations of ferric and aluminium solution mixture for 21 days. The salts being used were ferric chloride and aluminium sulphate with mass ratio of ferric to aluminium in the solution mixture was 3:1. After 21 days of exposure, the plants had shown that they could grow and survive in concentrations up to 450 mg/L Fe + 150 mg/L Al with about 66.7% of the total plants were withered. While, at the other concentrations of 600 mg/L Fe + 200 mg/L Al and 750 mg/L Fe + 250 mg/L Al, all plants were 100% withered. Therefore it is suggested, in future phytotoxicity study, the range that could be applied is from 0 mg/L Fe + 0 mg/L Al until 600 mg/L Fe + 200 mg/L Al to exactly determine the concentration range that the plants can survive.

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INTRODUCTION

Heavy metals are the most common inorganic contaminants exist in the environment. It enters the environment from a variety of domestic and industrial sources such as combustion by-products, traffic, mining and smelting activities, electroplating, waste disposal, urban effluent, sewage sludge, pesticides and fertilizers application (Ali, H., 2012; Sheoran, V., 2011; Vardanyan, L., 2008). Between those elements, mining is the one to be blame for heavy metal contamination of soils, sediments and water (Lesley, B., 2008; Sheoran, V., 2011) at which they may enter the food pathway to man, animals and plant life, thus can cause toxic in various degrees to them (Claveau-Mallet, D., 2013).

Bauxite mining can lead to iron and aluminium contamination to the environment. It can happen naturally (i.e. rain) and also by human (i.e. mining activity). Iron in drinking water and water supplies causes problems, such as giving reddish color, odor, discoloration of food and beverage, metallic taste, turbidity, staining of laundry and plumping fixtures, etc. (Bordoloi, S., 2011; Chaturvedi, S. and P.N. Dave, 2012). In addition, the conversion of iron to ferric hydroxide precipitate can generate toxic derivatives and this will lead to infection, neoplasia, cardiomyopathy, arthropathy, and various endocrine and neurode- generative disorders in human (Bordoloi, S., 2011). Likewise iron, aluminium also has the toxic influences which will lead to Parkinson's dementia, amyotrophic lateral sclerosis and Alzheimer's disease (Dzulfakar, M.A., 2011).

Due to the facts of toxicity effects of both metals, rectification technologies have been applied to reduce the concentrations of heavy metals from the polluted environments to the allowable limits. For examples, the World Health Organization (WHO) recommends a guideline value of 2.0 mg/L for total iron (WHO, 2011). While according to the Environmental Quality Act 1974 under Environmental Quality (Industrial Effluent) Regulations 2009, the acceptable conditions for discharge of industrial effluent or mixed effluent of standard A and B for iron is 1.00 mg/L and 5 mg/L while for aluminium is 10 mg/L and 15 mg/L. But, conventional methods are costly, labour and energy intensive, generate secondary waste or sludge and metal specific (Prajapati, S.K., 2012; Vardanyan, L., 2008). Thus, a cost-effective and environment friendly alternative should be featured and phytoremediation suit those characteristics.

Phytoremediation is a remediation technology that uses plants for decontamination of polluted sites either soils or waters (Ali, H., 2012). During the remediation, it involves different processes which are rhizofiltration,

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Australian Journal of Basic and Applied Sciences, 8(19) Special 2014, Pages: 168-171

phytostabilization, phytotransformation, phytoextraction and phytovolatilization. Some local studies were done to identify the potential of native plants towards lead contamination in soil and wastewater and arsenic contamination in soil respectively as in Table 1.

Table 1: Previous local study towards some native plants.

Researcher	Plant name and plant type	Contaminant	Medium	Performance
Selamat et al., 2011	*M. malabathricum* L (Terrestrial plant)	Lead	Soil	•Has high uptake capacity in root with BCF>1 for all exposure of lead
Tangahu et al., 2013	*S. grossus* (Wetland plant)	Lead	Wastewater	• Has BCF and TF greater than 1
Titah et al., 2013	*L. octovalvis* (Terrestrial plant)	Arsenic	Soil	• Could uptake and accumulate arsenic in plant tissue at once

Besides those plants, *Lepironia articulata* is another native plant that has the ability to remediate iron and aluminium from contaminated areas since it was found in bauxite mining areas in Sungai Jemberau, Tasik Chini, Pahang (Ismail, N.I., 2013). It is an emergent plant as depicted in Figure 1 (a). *L. articulata* is a perennials plant with rhizome horizontally creeping and woody. Figure 1 (b) – 3 (e) show the physical appearance of *L. articulata*.

(a) (b) (c) (d) (e)

Fig. 1: (a) Habitat of *Lepironia articulata* in Tasik Chini, Pahang and physical appearances for *L.articulate* (b) the whole plants, (c) spike, (d) hollow stems (e) roots

The aim of this preliminary test was to estimate the range of ferric [Fe (III)] and aluminium [Al (III)] concentrations that the *Lepironia articulata* can grow and survive. Thus, the results from this study can be used in future phytotoxicity study that aims to determine the uptake and accumulation of Fe and Al in plants. Before the preliminary test was conducted, the analysis of soil mining collected from Tasik Chini was done in order to determine the mass ratio between iron and aluminium. From the analysis, it was found that the mass ratio of iron to aluminium was 3:1 (Ismail, N.I., 2013). The result from this analysis was used during the preliminary test of *L. articulata*.

MATERIALS AND METHODS

The preparation of synthetic mining wastewater, sand, plants and the preliminary test was done in a greenhouse in UKM, Malaysia. Pails of 3 L were used as batch reactors and synthetic mining wastewater acted as contaminant at which the salts being used were iron (III) chloride hexahydrate $(FeCl_3.6H_2O)$ (Friendemann Schmidt, U.K) and aluminium sulphate ($Al_2(SO_4)_3.16H_2O$) (R & M Marketing,U.K). Mass ratio between ferric and aluminium was set as 3:1 based on the findings from a previous analysis (Ismail, N.I., 2013). 18 healthy plants of 42 days old were used where three plants were planted in each pail as in Table 2.

Table 2: Concentration of heavy metals in a pail.

Pail no.	Pail 1	Pail 2	Pail 3	Pail 4	Pail 5	Pail 6
Concentration of heavy metals in a pail						
mg/L Fe	0	150	300	450	600	750
mg/L Al	0	50	100	150	200	250

The observation was conducted on Day 0, and Day 21. After 21 days of exposure, the percentage of withered plants in each concentration was determined relative to the total number of plants in the pail using the following equation

$$\%\ \text{of withered plant} = \frac{\text{number of withered plant}}{\text{number of total plant}} \times 100 \quad (1)$$

Australian Journal of Basic and Applied Sciences, 8(19) Special 2014, Pages: 168-171

RESULTS AND DISCUSSION

Table 3 summarizes the observation together with the physical appearance of *L. articulata* during the preliminary test when exposed to the mixture of ferric and aluminium. Withered plants occurred on Day 7 starting from 300 mg/L Fe + 100 mg/L Al until 750 mg/L Fe + 250 mg/L Al. After 21 days of exposure, all plants were dried especially on 600 mg/L Fe + 200 mg/L and 750 mg/L Fe + 250 mg/L Al. While one and two plants were dried on 300 mg/L Fe + 100 mg/L Al and 450 mg/L Fe + 150 mg/L Al respectively. While the percentage of withered plants for different concentrations of ferric and aluminium after 21 days of exposure is depicted in Figure 2.

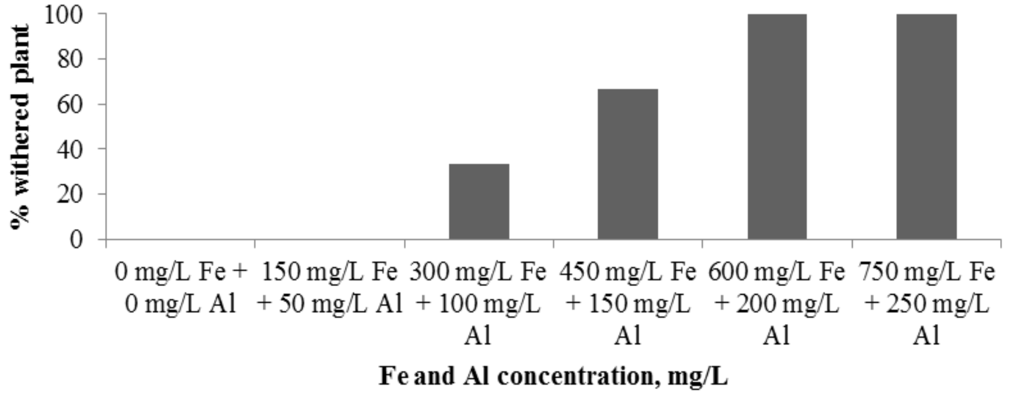

Fig. 2: Percentage of withered plants for different concentrations of Fe and Al.

Table 3: Plant physical observation during preliminary test for *L. articulate.*

Time of exposure (Day)	Heavy metals concentration					
	0 mg/L Fe + 0 mg/L Al	150 mg/L Fe + 50 mg/L Al	300 mg/L Fe + 100 mg/L Al	450 mg/L Fe + 150 mg/L Al	600 mg/L Fe + 200 mg/L Al	750 mg/L Fe + 250 mg/L Al
00	 Plants were healthy	 Plants were healthy	 Plants were healthy	 Plants were healthy	 Plants were healthy	 Plants were healthy
21	 Plants were healthy 1 young and healthy plant grew	 Plants were healthy 1 young and healthy plant grew	 2 plants were healthy 1 plant was withered and dried	 1 plant was healthy 2 plants were withered and dried	 Plants were withered and dried	 Plants were withered and dried

There were no withered plants on 0 mg/L Fe + 0mg/L Al and 150 mg/L Fe + 50 mg/L Al. About 33.3% and 66. 7% of withered plants on 300 mg/L Fe + 100 mg/L Al and 450 mg/L Fe + 150 mg/L Al respectively. While the plants were 100% withered in the rest mixture concentrations.

Conclusions:

The results showed that as the concentrations of the mixture of ferric and aluminium increased, the withering symptoms and dried plants of *L. articulata* were also increased. *L. articulata* has the ability to survive up to 150 mg/L Fe + 50 mg/L Al with 0% of withered plant. In addition, the plant did not survive at 600 mg/L

Fe + 200 mg/L and 750 mg/L Fe + 250 mg/L Al. Thus, for future phytotoxicity study, the range is from 0 mg/L Fe + 0 mg/L Al until 600 mg/L Fe + 200 mg/L Al.

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