LEAD AVAILABILITY AND ABSORPTION BY GREEN KYLLINGA (*Cyperus kyllingia* L.), CORN (*Zea mays* L.), AND AMARANTH (*Amaranthus tricolor* L.) IN GEDONGMENENG SOIL TREATED WITH A LEAD-CONTAINING ELECTRONICS INDUSTRIAL WASTE AND LIME

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ABSTRACT

LEAD AVAILABILITY AND ABSORPTION BY GREEN KYLLINGA (Cyperus kyllingia L.), CORN (Zea mays L.), and AMARANTH (Amaranthus tricolor L.) IN GEDONGMENENG SOIL TREATED WITH A LEAD-CONTAINING ELECTRONICS INDUSTRIAL WASTE AND LIME. *Lead availability and absorption by plants are governed by lead inputs and soil properties such as pH. This research was to evaluate lead availability and absorption by green kyllinga (Cyperus kyllingia L.), corn (Zea mays L.), and amaranth (Amaranthus tricolor L.) in soil treated with a lead-containing electronics industrial waste and lime. Soil sample was mixed thoroughly with electronics industrial waste at rates ranging from 0 to 40 ton ha*$^{-1}$ *and or* $CaCO_3$ *at 0 or 5 ton ha*$^{-1}$*. The plants were grown in the mixtures after a 1-week incubation at 40% moisture content. After a four-week growing time in a glasshouse, Pb availability in the soil and Pb accumulation in the plant shoots were determined. The results showed that available Pb was lower in limed soil than in unlimed soil regardless of the plants grown, in a negative relation with the change in soil pH. Addition of electronics industrial waste increased available Pb in soil. Except in amaranth soil, Pb accumulation was lower in limed than in unlimed soil. In amaranth soil, Pb accumulation was higher in limed than in unlimed soil. Lead accumulation in plant shoots was negatively correlated with the increase in soil available Pb of waste origin.*

Keywords: industrial waste, lime, lead, lead absorption, tropical plants

INTRODUCTION

Being harmful to biota (Djuangsih, 1992; Alloway, 1990a; Baker, 1990; Steinnes, 1990), heavy metals are now considered to be one of the main objects in environmental research. Alloway (1990b) suggested that problems related to heavy metal toxicities may be more serious in the future in path with development of modern industries. This trend is attributed to the increasing use of heavy metals by industries and greater industrial wastes produced as factories' byproducts. Several authors have documented heavy metal contents in various wastes and their potential effects on biota and also their uses in agriculture (Alloway, 1990c; Allaway, 1986; Kardos *et al.*, 1986).

Heavy metals in soils are originated from natural and anthropogenic sources. Except in particular soils with abundant sources of heavy-metal-containing soil minerals, their natural sources are usually scarce. Conversely, anthropogenic sources are considered to be the main sources of heavy metals in the environment. Direktorat Penyelidikan Masalah Air (1983) reported that a great deal of modern industries are significant sources of heavy metals. Salam et al. (1996) analyzed 12 industrial wastes sampled from waste treatment units of several factories in Jakarta and revealed that most wastes contained high amounts of heavy metals. Electronics industrial waste of PT Indomacin Jakarta contained about 130 mg Pb kg^{-1}. It is also reported lately that contamination of soils and vegetables by Pb emitted by motor vehicles was evident in areas adjacent to major roads (Markus and McBratney, 1996; Akhter and Madany, 1992; Davies, 1990; Minami and Araki, 1975). All these metals may accumulate in human tissues directly or indirectly through food chains.

One important route for heavy metals to reach human tissues is their accumulation in soils. In soils, heavy metals may actually dissolve into soil water or be adsorbed by soil solids such as soil clay and organic matter. Dissolved metals are easily absorbed by plant roots. Conversely, adsorbed metals are relatively unavailable to plants because plants roots need to spend more energy in using these metal forms. The higher the soluble metals in soils, the higher the metals absorbed by plants roots. Increasing the adsorption of metals by soil solids may lower the intake of heavy metals by humansthrough food chains.There are several useful methods suggested by researchers to increase heavy metal adsorption by soil solids (Salam et al., 1997; Ma et al., 1995; 1993; Rodella et al., 1995; Salam, 1995a, 1995b;

Sumner et al., 1991; Alloway, 1990a). Among these, liming is considered appropriate for tropical soils, that have relatively acid pH and high pH-dependent charges. The increase in soil pH driven by lime addition may increase the number of H dissociation from soil functional groups (Salam and Helmke, 1998; Salam et al., 1997; Davies, 1990). This process may increase the soil adsorption capacity with respect to heavy metals. By this way liming may eventually lower heavy metal solubilities in soils and decrease metal absorption by plant roots.

This research was to evaluate lead availability and plant absorption in Gedongmeneng soil treated with electronics industrial waste and lime planted with green kyllinga, corn, and amaranth.

MATERIALS AND METHODS

This research was conducted in a glasshouse of The Faculty of Agriculture, The University of Lampung, Bandar Lampung from April to June 1997. Soil sample was collected from Ap horizon (0-30 cm) of The University of Lampung Polytechnics Experimental Farm in Hajimena, Natar, South Lampung. Soil sample was air-dried, ground, sieved to 2 mm, and thoroughly mixed before being used.

. Treatments were arranged factorially with 4 replications. The first factor was electronics industrial waste, given at (ton ha^{-1}): 0 (W-0), 10 (W-1), 20 (W-2), and 40 (W-3). Electronics industrial waste was taken from electronics factory of PT Indomacin in Jakarta by a technician from Kantor Pengkajian Perkotaan dan Lingkungan (KPPL) Jakarta. The second factor was lime ($CaCO_3$), given at 0 (L-0) and 5 ton ha^{-1} (L-1). Treatment materials were thoroughly mixed with soil sample (400 g per pot, 105 ^{o}C oven-dry equivalent), moisted with water to 40%, and incubated at room temperature. Basal fertilizers (Urea, TSP, and KCl) were given at 100 kg ha^{-1}. Green kyllinga was then planted after a 7 days incubation. Similar experiments was also conducted with different plants: corn for the second experiment and amaranth for the third experiment. Seedlings of green kyllinga and amaranth were prepared previously before planting while corn was planted directly using seeds. All plants were grown for 4 weeks.

Soil samples were extracted with 0.005 *M* DTPA and analyzed for Pb with *flame atomic absorption spectrophotometer* (*flame* AAS) (Baker and Amacher, 1982). Plant shoots were harvested, oven-dried (3 days at 60 ^{o}C), and weighed before being analyzed. To determine Pb content in shoots, dry plant materials were ground and thoroughly mixed. About 1 g of the ground plant materials was ashed in a muffle furnace at 500 ^{o}C. A 5 mL of *N* HCl was added after 6 hours, after which the mixture was put on a hot plate until boiling. The mixture was then transfered quantitatively through a Whatman paper No. 42 with a 5 mL *N* HCl and diluted with distilled water to 50 mL. Concentration of Pb was determined by using *graphite fornace* AAS.

RESULTS AND DISCUSSION

Addition of lime significantly increased the soil pH (Figure 1), similar to those reported previously by Salam et al. (1997) and Salam (1995a). In accordance with this phenomenon, the availability of Pb was mostly lower in limed soils than that in unlimed soils regardless of the plant grown (Figure 2). This phenomenon is in agreement with those reported previously (Salam et al., 1997). Lead availability was generally decreased by lime treatments.

The decrease in soil pH by lime addition was due to the neutralization of H^+ and production of OH^-. OH^- ions may have driven the dissociation of H^+ from various functional groups in soils and formed neutral H_2O and increased the number of negative charges that eventually associated with Pb ions. Lead ions were held relatively strongly by this association, hence, they were relatively difficult to extract. As a result, part of the Pb was not available to plant root absorption due to liming.

To a small extent the addition of electronics industrial waste also increased the soil pH (Figure 1). This phenomenon was due to the liming effect of the waste employed. The waste used in this experiment may have been neutralized in waste treatment units and showed a relatively high pH. However, the increase in soil pH caused by waste addition was not related to the decrease in Pb availability (Figure 2). Waste addition, conversely, increased the Pb availability in soil. These phenomena indicate that the effect of industrial waste on Pb availability was apparently more important than on soil pH. As a result, lowering the availability of Pb needs more lime inputs.

The presence of plant roots may have modified soil pH in the rooting zones due to root excretion such as H^+, OH^-, HCO_3^-, and organic acids. However, no difference in pH was observed among soil planted with different plants (Figure 1). This fact indicates that liming gave greater effects on soil pH than did plant root exudates.

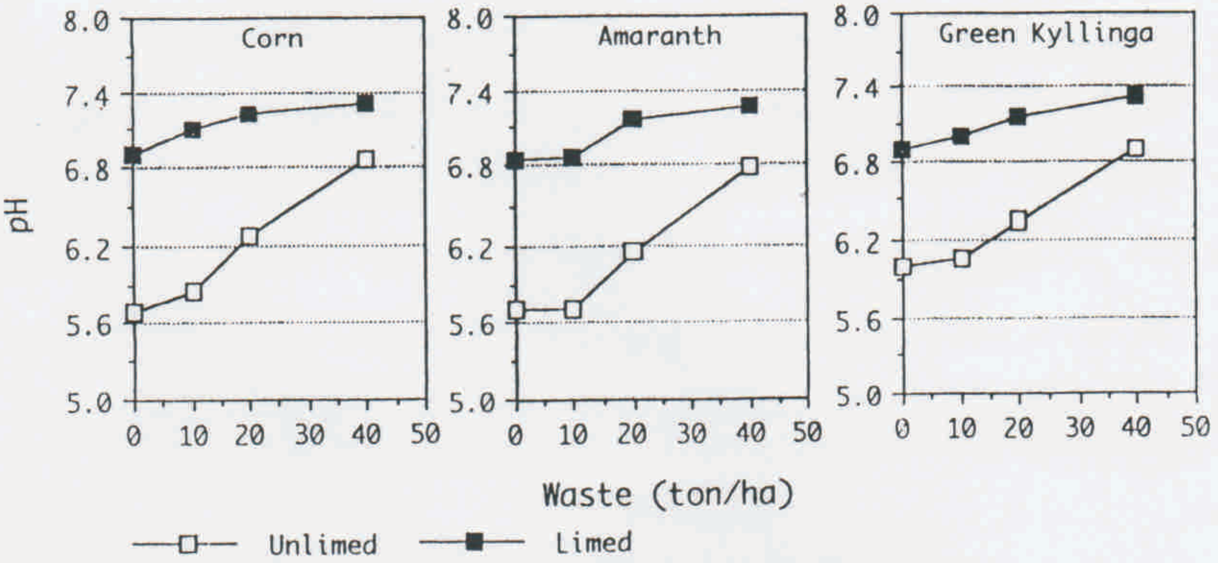

Figure 1. Changes in pH of the root-zones of some tropical plants as affected by lime and industrial waste additions.

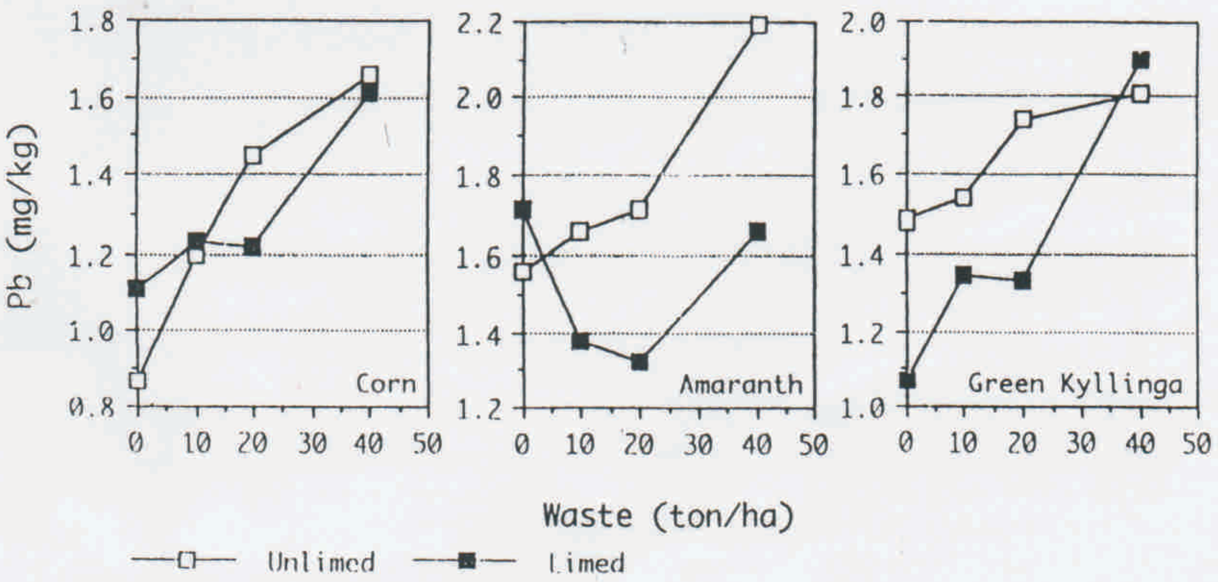

Figure 2. Changes in available Pb in the root-zones of some tropical plants as affected by lime and industrial waste additions.

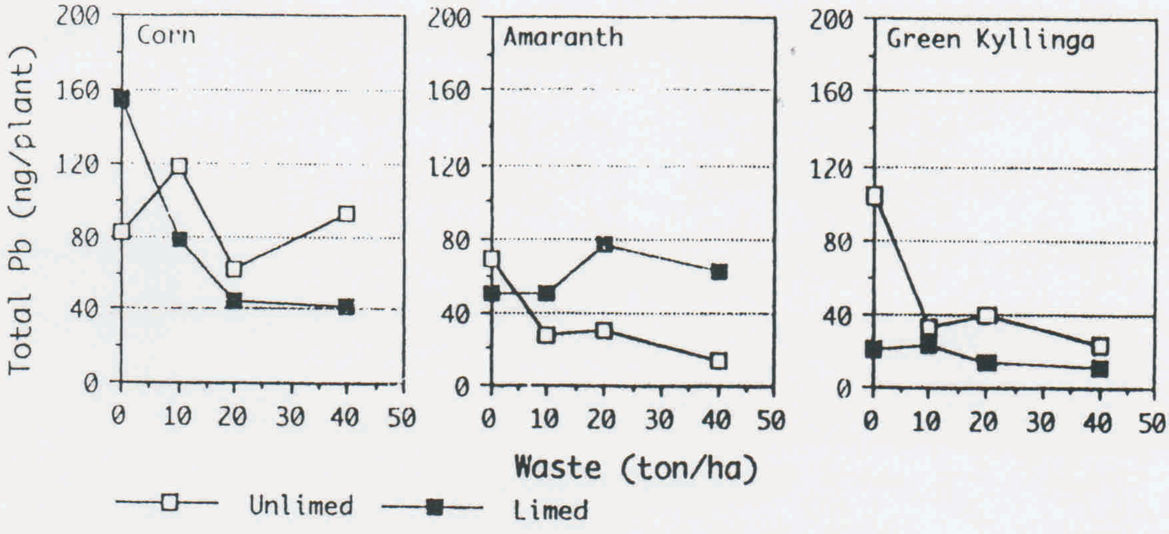

Figure 3. Changes in accumulation of Pb in shoots of some tropical plants from soil treated with lime and industrial waste additions.

Except for amaranth, plant absorption with respect to Pb was affected by liming (Figure 3). Lead accumulation in corn and green kyllinga shoots was lower in limed soils than those in unlimed soils. This phenomenon was consistent with Pb availability data (Figure 2). Lower Pb accumulation in these plants was directly related to the lower Pb availability caused by liming. Greater Pb in limed soils were held stronger by soil particles; consequently, lower amount of Pb was taken by plant roots from limed soils. The higher accumulation of Pb by amaranth on limed soil than that on unlimed soil was probably related to the fact that amaranth was one of the heavy-metal accumulator (Alloway, 1990d). Its absorbing power was mostly related to its physiological properties.

Lead accumulation was not in a linear correlation with the increase in soil Pb availability due to waste addition (Figures 2 and 3). Lead accumulation in plant shoots decreased as Pb availability increased. This phenomenon was probably related to the toxic effects of Pb ions. Lead ions might have been retained by root cation exchange capacity (CEC) or accumulated in plant roots. As a result, only a small part of absorbed Pb was traslocated to plant shoots. Because waste addition increased the soil pH, root CEC might be higher at higher rates of waste addition. This process might have lowered lead accumulation in shoots when waste was added at high rates.

CONCLUSIONS

Available Pb was lower in limed soils than in unlimed soils regardless of the plants grown, in a negative relation with soil pH changes. Addition of electronics industrial waste increased available Pb in soil. Except in amaranth soil, Pb accumulation was lower in limed than in unlimed soils. Lead accumulation in plant shoots was negatively related with the increase in soil available Pb of waste origin.

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