11th ESAFS

PROCEEDINGS OF

11th International Conference The East and Southeast Asia Federation of Soil Science Societies

LAND FOR SUSTAINING FOOD AND ENERGY SECURITY

21-24 October, 2013

IPB International Convention Center - Bogor, Indonesia

Indonesian Society of Soil Science

ISBN 978-979-19904-1-7

ESAFS

East and Southeast Asia Federation of Soil Science Societies

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Land for Sustaining Food and Energy Security

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INDONESIAN SOCIETY OF SOIL SCIENCE

Paper and posters presented
at 11th International Conference of
The East and Southeast Asia Federation of Soil Science Societies
IPB International Convention Center, Botani Square
Bogor, Indonesia
21-24 October 2013

ISBN 978-979-19904-1-7

Publish by :
Indonesian Society of Soil Science
Sekretariat Gedung BPN RI, Jl. H. A. Salim 54 Jakarta Pusat
e-mail: sekretariathiti_pusat@yahoo.co.id ; web : http://www.hiti.or.id

Printed by:
Indonesian Society of Soil Science
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IN SITU INACTIVATION USING AMELIORANTS AND FERTILIZERS AT RATIONALE DOSAGE AS A NON-INVASIVE REMEDIATION STRATEGY FOR HEAVY METAL CONTAMINATED AGRICULTURAL-LAND: A CASE STUDY FORA LEAD SPIKED-ARABLE SOIL

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Introduction

Plant can accumulate lead (Pb) at a high concentration without significant vegetative changes. Therefore, it is more harmful for human health, especially for the *vegetarian*. Remediation strategies for heavy metal (HM) contaminated-lands are usually expensive and invasive (*ex situ*) as they apply excavation works, an almost impossible technique to be practiced by farmers. For arable soils, *in situ inactivation*, a remediation technique that used inexpensive chemicals without invasive works to reduce contaminant solubility (Vangronsveld and Cunningham 1998),can be considered as an alternative strategy. It was reported that application of ameliorants such as organic matter, alkaline matter, phosphates, carbonates, and oxides increased soil sorption capacity to HM, reduced crop uptake of HM, and thus reduced HM transfer to the food chains. This study was aimed at to evaluate the effectiveness of lime, organic matter and NPK fertilizers, at dosages normally recommended for crop cultivation, from the point of view to reduce soil Pb and plant Pb concentration using tomato as the test plant.

Materials and Methods

A 100-day greenhouse experiment in CRD consisting of 3 rates of rationale dosage of ameliorants and fertilizers (RDAF) [0, 50, 100%] and 4 levels of soil Pb spike [0, 187.5, 375, 750 mg Pb.kg^{-1}soil, using Pb $(CH_3COOH)_2.3H_2O$] in triplicate was conducted. The 100% rate of RDAF applied was4 ton.ha^{-1} dolomite, 30 ton.ha^{-1} cow dung, 150 kg.ha^{-1} N [½ Urea + ½ $(NH_4)_2SO_4$], 150 kg.ha^{-1} P_2O_5 (SP-36), and 100 kg.ha^{-1} K_2O (KCl). The soil used was a top 20 cm fluventiceutrudept with the following properties: 52.45% clay content; pH H_2O 1:16.30;2.37% org-C;0.09%$N_{Kjeldahl;}$11.82 mg.kg^{-1}$P_{Bray\#1}$;0.20, 3.87, and 0.65 cmol(+).kg^{-1}exch-K, -Ca, and -Mg respectively; 9.53 cmol(+).kg^{-1}CEC, and60.37 mg.kg^{-1}$Pb_{aquaregia}$.

At day#1, air dried soils equal to 5 kg (105^{o}C) were mixed with Pb spike solutions. At day#8, soils were mixed with dolomite and cow dung, dewatered, and incubated for 4 weeks. At day#36, all P and ½ dose of N and K were applied, incubated for 2 days, and then 3 weeks-seedling of tomato were transplanted. At 31stday after transplanting (DAT), another ½ dose of N and K were applied. At 100 DAT, the tomato shoots were cut at 1 cm above soil surface, washed with aquadest, put in an oven at 60 ^{o}C, and recorded as plant dry weight (DW_{ts}). During experiment, soil water content was maintained at around field capacity using aquadest. At harvest, analyses were done for soil $Pb\text{-}_{NH4OAc\text{-}EDTA}$(extracted with 0.5 *M* NH_4OAc + 0.02 *M* EDTA pH 4.65) and tomato shoot Pb concentration (Pb_{ts}, dry ashing, 0.2 *M* HNO_3).

Results and Discussion

Table 1.At 100% RDAF treatment, while plant DW_{ts} significantly ($p<0.01$) increased from 9.26 to 45.69 g.pot^{-1}, a significant ($p<0.01$) decrease in plant Pb_{ts} [from 47.57 to 36.24 μg.g^{-1}, 24%] was measured, even though soil $Pb_{NH4OAc\text{-}EDTA}$increased11% from 84.71 to 94.40 mg.kg^{-1} ($p>0.05$) as compared to the control soil (0% RDAF). However, in unspiked-soil, application of 100% RDAF decreased 50% of the soil $Pb_{NH4OAc\text{-}EDTA}$from 11.57 to 5.78 mg.kg^{-1}. This shows that the effects of in situ inactivation using RDAF on Pb active fractions was only effective in the unspiked-soil. This probably related to increase in the amount of Pb sorption sites and capacity in soil solid phase (Gomes *et al*. 2001; Sauvé *et al*. 2000) due to the increase in soil

pH [from 6.6 to 7.8*], soil org-C [from 1.20 to 2.30%*], and soil CEC [from 16.22 to 19.31 cmol(+).kg^{-1}*].* Data not shown. Although it does not change the total content of soil HM, through sorption mechanism application of in situ inactivation technique will transformed the active fractions of HM cations into those that are geochemically more stabile-fractions, thus decreasing their solubility and toxicity (Hettiarachchi *et al*. 2001). Desorption process may be occurred, however, it needs much higher activation energy then for sorption, therefore at normal soil temperature the desorption rate will be much lower then the sorption one (McBride 1989).

Table 1 Effects of in situ inactivation from amelioration and fertilization at 0, 50, and 100% rationale dose (RDAF) for tomato cultivation in a Pb spiked-soil on soil $Pb_{NH4OAc-EDTA}$,plant dry weight (DW_{ts}), and plant shoot Pb concentration (Pb_{ts})

Amelioration Fertilization (% RDAF)	Soil Pb spike treatments (mg.kg^{-1})				
	0	187.5	375	750	*Average*
	Soil $Pb_{NH4Oac-EDTA}$(mg.kg^{-1})				
0	11.57	44.51	79.61	203.13	*84.71*b
50	9.26	58.12	124.41	234.73	*106.63*a
100	5.78	45.46	111.74	214.62	*94.40* ab
	Tomato shoot dry weight (DW_{ts}, g.pot^{-1})				
0	9.25	11.36	8.95	7.47	*9.26* c
50	38.88	45.69	42.25	32.65	*39.87* b
100	38.62	53.30	46.17	44.67	*45.69*a
	Tomato shoot Pb concentration (Pb_{ts}, µg.g^{-1})				
0	23.99	29.99	57.66	78.65	*47.57*a
50	22.98	25.66	51.00	77.98	*44.41*a
100	20.66	23.33	48.99	51.99	*36.24*b

Conclusions

The 100% RDAF treatment very significantly decreased [50%]soil $Pb_{NH4OAc-EDTA}$in the unspiked-soil and the average tomato shoot Pb_{ts} concentration [24%] as compared to the control soil. Amelioration and fertilization at recommended dosage for crop cultivation was also effective and prospective as a remediation strategy for Pb contamination in arable soils.

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ENVIRONMENTAL CHANGES THAT MAY OCCUR ON THE YOGYAKARTA SAND BEACH CAUSED BY THE IRON MINING

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Abstract

There is a plan to mine and extract the metallic minerals from the sand beach in Yogyakarta, Java Island, Indonesia. The existing utilization of the land is as agriculture that done by local farmers for more than two decades. It is predicted that the environmental changes may occur over the mining and processing of the iron sand material in this area. The tailings produced would be characterized as fine size, low density and still remaining metallic minerals. As wind blows from the sea every time towards terrestrial may fly the light tailing materials in higher elevation and more far range, thus it potentially endanger the broader area where people live.

Introduction

The south coast land of Yogyakarta region, Java Island, Indonesia developed on the combination processes of the transported the Merapi volcano materials on the south coast, ocean waves and monsoon wind resulting deflation process the grains of sand towards the shore (Prastistho and Nurcholis, 2000). The sorting process on this material by wave force that occur in long period produces an accumulation of metallic minerals with a high density, such as: magnetite, hematite, ilmenite, vanadinite, zircon, titanite and rutile, that have a high economic value if these will be mined. On the other hand, people in this area have managed the land that has very poor nutrient but good physical properties and excellent beaches climate to be productive agriculture land. According to a mining activity that would be planned in this area, this study was aimed to predict environmental changes that may occur over the mining and processing of the iron sand material.

Materials and Methods

The study was conducted by field observations on the coast of the planned mining, and detail study was conducted on the location of the pilot plant to understand the environment area after mining activity. Minerals and elements content in the tailing resulted from the pilot plant were then analyzed.

Results and Discussion

Most of the coast land area was cultivated with many kinds of crops by the farmers that live on the north of this area. They manipulated the soil developed on the sand dunes which characterized with coarse materials (Sukirno, 2008) by adding the clay and organic materials in order to create a good condition for plant growth. The similar effort was also done by the farmers in Thailand farmer (Wada, 2005) and in Hainan China (Zhao et al,, 2005).

Mine activity would be done by excavating the sand until three meters in depth, then it would be processed at the site, and the tailings would be returned back as a material for reclamation process (Figure 1). In order to maximize the extraction process, the sand would be performed by grinding previously before iron minerals separation that would be done by providing a magnetic field. Then separation of the remaining metallic minerals would be done by the difference of each mineral density, respectively. So that the tailings produced would be characterized as fine size, low density and still remaining metallic minerals. As wind blows from the sea every time towards terrestrial may fly the light tailing materials in higher elevation and more far range, thus it potentially endanger the broader area where people live.

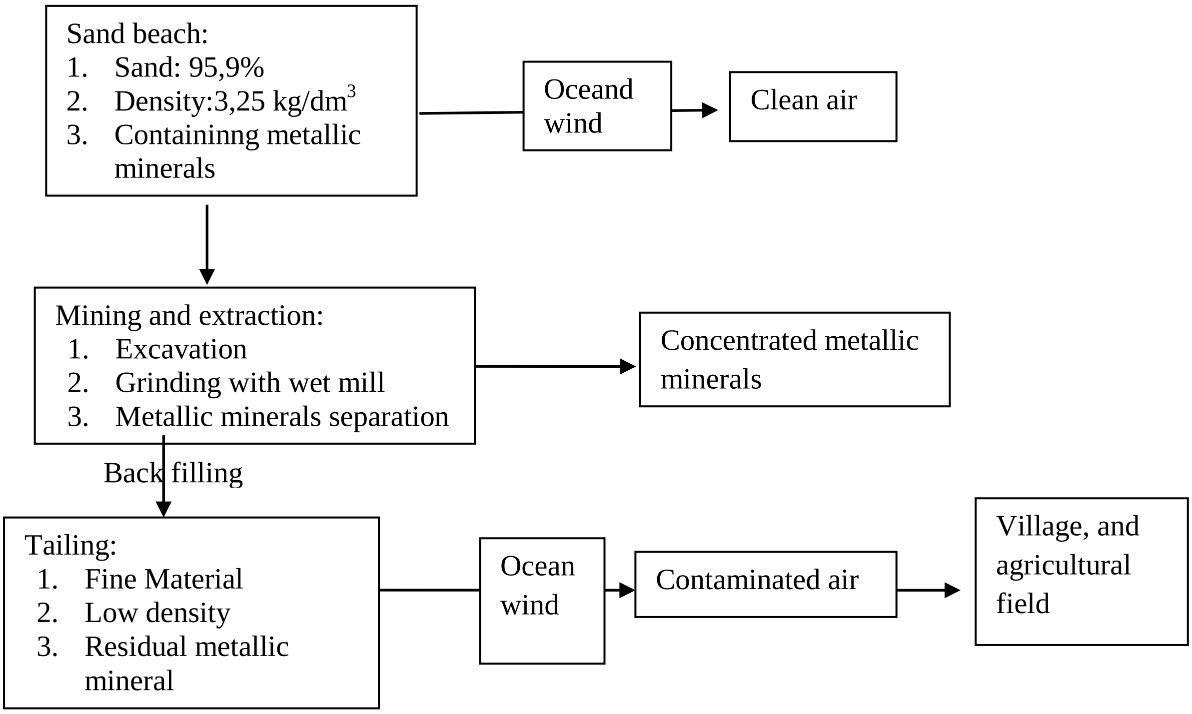

Figure 1. Metallic minerals separation on the Iron sand and the effect on the environment

Conclusion

Mining operation that will be done on the iron sand beach in Yogyakarta might cause the flying of the fine tailing materials. It potentially result environmental problem on the populated area that located on the north area of mining land.

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