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INCREASING PRODUCTIVITY OF THE LEAD CONTAMINATED PADDY SOIL BY USING HUSK BIOCHAR AND AZOLLA IN DAGANG KELAMBIR VILLAGE TJ. MORAWA INDONESIA

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ABSTRACT
Lead (Pb) is an element that is commonly used in various industries and is always present in various forms of the pollution, whether solid, liquid or gas (air), efforts to reduce Lead levels are very necessary considering this metal has many sources both naturally and as factory residue, fertilizers and pesticides. This research aims to restore and increase the productivity of the polluted rice fields by producing Pb-free rice. This study used a 2-factor randomized block design with 4 replications, the first factor was Biochar application; without Biochar (B0) and with Biochar rice husk (B1). The second factor using Azolla, namely; without Azolla (A0), with *Azolla pinnata* (A1) and *Azolla mycrophylla*. The results showed that giving Biochar rice husk and Azola was able to increase production up to 7.10 tons / ha, up 10% from control and reduce lead to 43.9% and the best azolla for paddy lead contaminated was *Azolla mycrophylla.*

KEY WORDS
Paddy, lead, productivity, biochar, azolla.

Sustainable wetland management and increased production are challenged by the emergence of degraded paddy fields, reduced the quality and productivity of the land, and there are also many conversions of paddy fields to plantations promised large income for farmers, hence becomes a concern about rice food shortages and has become the national goal for rice self-sufficiency in Indonesia (Sulaiman et al. 2019).

The emergence of the factories in agricultural areas, especially in rice fields, and excessive use of the agrochemical fertilizers which contain lots of compounds containing heavy metals, especially lead (Pb), have become a concern of the metal contamination in lowland rice, as many have reported, would have a negative effect on human (Sulaiman et al. 2019)

Lead has a terrible impact on humans when crosses the threshold (10 -25 μg / 100 ml), especially for children. Among them are affecting cognitive function, learning ability, shortening height, decreasing hearing function, affecting behavior and intelligence, damaging the function of organs, such as the kidneys, nervous system, and reproduction, increasing blood pressure and affecting brain development. It could also cause anemia (Sudarmaji et al. 2006).

Biochar is the product of biomass which undergoes a thermolysis process so that it changes the carbon structure to become aromatic and resists the decomposition process for a long time and becomes a long-term carbon storage. Biochar has wide pores, the best place for increased bacterial activity, fungi that produce a lot of organic acids (Tumuluru, 2011), the

ability of biochar to absorb CO_2, carbonates, bicarborbonates and high content of alkaline cations which could be exchanged to make biochar has the best ability to absorb heavy metals (Park et al. 2011; Cui et al. 2011; Jiang et al. 2012; Moo et al. 2013; Ferreiro, 2014; Xu et al. 2016)

Biochar has properties like organic matter, has a variable charge, the functional group of organic matter could be positively or negatively charged depending on soil pH, therefore the ability to absorb cations also changes depending on the load on the soil complex (Havlin et al. 2005). He also reported that liming increases soil pH from 4.20-5.99, increases the availability of Ca and Mg, and the utilization of biochar also has similarities with calcite lime, because biochar has a pH between 8.5 and 9 with a high alkaline content could be used to increase pH (Hidayat, 2017).

Organic carbon biochar is resistant to weathering processes, biochar could last a long time in the soil, adding biochar could increase production by improving soil physical, chemical and biological properties (Chan et al. 2009), and widely reported that biochar increases soil pH and cation exchange capacity. (Liang et al. 2006). Biochar also contributes negative ions to the soil, and ions could act as a buffer for the soil so that its application could increase the efficiency of nitrogen fertilization (Chan et al. 2009).

Rice husk biochar has a fairly wide surface area and is very porous, and has a variable charge hance has a buffer effect on high-pH soils, and the rice husk given was 3.3% weight could reduce alkaline soil pH (Shrestha, et al. 2019).

Rice husk biochar is also able to increase land productivity and fertilizer efficiency, as reported by Slavich et al (2011) that rice husk biochar increases land productivity in Aceh from 4.01 tonnes / ha to 6.82 tonnes / ha with an increase in the efficiency of N fertilization from 20.7 - 24.6 dry grain / kg N in agriculture 2010-2011.

Azolla is a fern plant that is rich itrogen when applied continuously to paddy fields, able to replace the use of urea with a nutrient supply of up to 4-60 kg / ha equivalent, and could increase land productivity (Talley et al. 1981; Kannaiyan 1982)

There are several species of azolla, namely; *Azolla pinnata*, *Azolla mycrophylla*, *Azolla Filiculoides*, *Azolla caroliniana*, *Azolla* mexicana, *Azolla Africana*, *Azolla nilotica*. *Azolla rubra* R. Br and commonly found in Asia are *Azolla pinnata* and *Azolla microphylla*, both commonly used as bioferlizers, and *Azolla microphylla* are the most active species at high temperatures (38^0C) (Kannaiyan 1982)

Besides having the ability to supply azolla nutrients, it also has the ability to absorb heavy metals Pb, Cd, Cu, Ni, Zn (Rakhshaee et al. 2006; Ganji et al 2005), Cr (Arora et al. 2006), Cs, Sr (Mashkani and Ghazvini, 2009), Hg (Bennicelli et al. 2004). This ability is due to the presence of pectin in specific vacuums in azolla which contains phtochelatin protein which has the ability to absorb heavy metals.

Arora et al. 2006, conducted tests on several types of azolla to find out which one is the best for absorbing Cr, from the results of the study it was found that *Azolla microphylla* had a higher Cr absorption ability than *Azolla pinnata* and *Azolla filiculoides* at 14931 ppm with a BCF value of 4167.

The large potential for the use of biochar rice husk and azolla in remediating contaminated rice fields so as to achieve maximum production, it is necessary to seek the utilization technology to improve the quality and quantity of Pb contaminated paddy field production.

METHODS OF RESEACH

This research was conducted in farmers' land in Dagang Kelambir Village, Tanjung Morawa Indutrial Area, with high Pb consentration (Simangunsong, 2009) an altitude of 25 M above sea level, with inceptisol soil types (Fig.1) and analysis in the BPTP laboratory Indonesia Standart Commitee. This research was started in July-February 2015. The biochar material of rice husk was terminated with BT 01 tool. The tools used were the couldgkuk and Jetor for processing soil, sickle, jetor and thaser thresher rice, wood and labels for pancouldg samples. The pyrolyzer is a drum that has a hole at the bottom and is given an inlet and

outlet and is given a water cooler so that the ash content is not high. The materials used are Azolla pinnata and Azolla microphylla, Urea, SP36 and KCl as basic fertilizers and others.

This study used a factorial randomized block design method with selected treatment of the results of the first stage research, namely:

Biochar factor (B), consists of two types; Without Biochar (B0), Biochar rice husk (B1). Azolla factor (A), consists of two types; Without azolla (A0), Azolla pinnata,(A1), Azolla microphylla (A2).

The nursery is prepared 25-30 days before planting, and the seeds are sown over the prepared nursery. Five days after sowing, the nursery is watered about 1 cm high for two days, and water continuously as high as 5 cm. occasionally the nursery needs to be dried hance the roots are not too long. Seedlings can be transplanted after 15-17 days after sowing and planted with a tile system and spacing 20 x 20 cm

Biochar was given according to the treatment in 1 day incubation until the water was implanted into Biochar, and given 100 grams of azolla, grown for 2 weeks until the plot surface was covered with azolla. 10 samples were made randomly after the rice was 1 month growth. Parameter observed ware pH, organic Carbon, Pb- total and available, Number of productive tillers (stems), Number of Grain Contains / Panicles (grain), 1000 grain weight (g), milled dry grain (GKG) (kg / Ha), Consentration Pb in husk and milled.

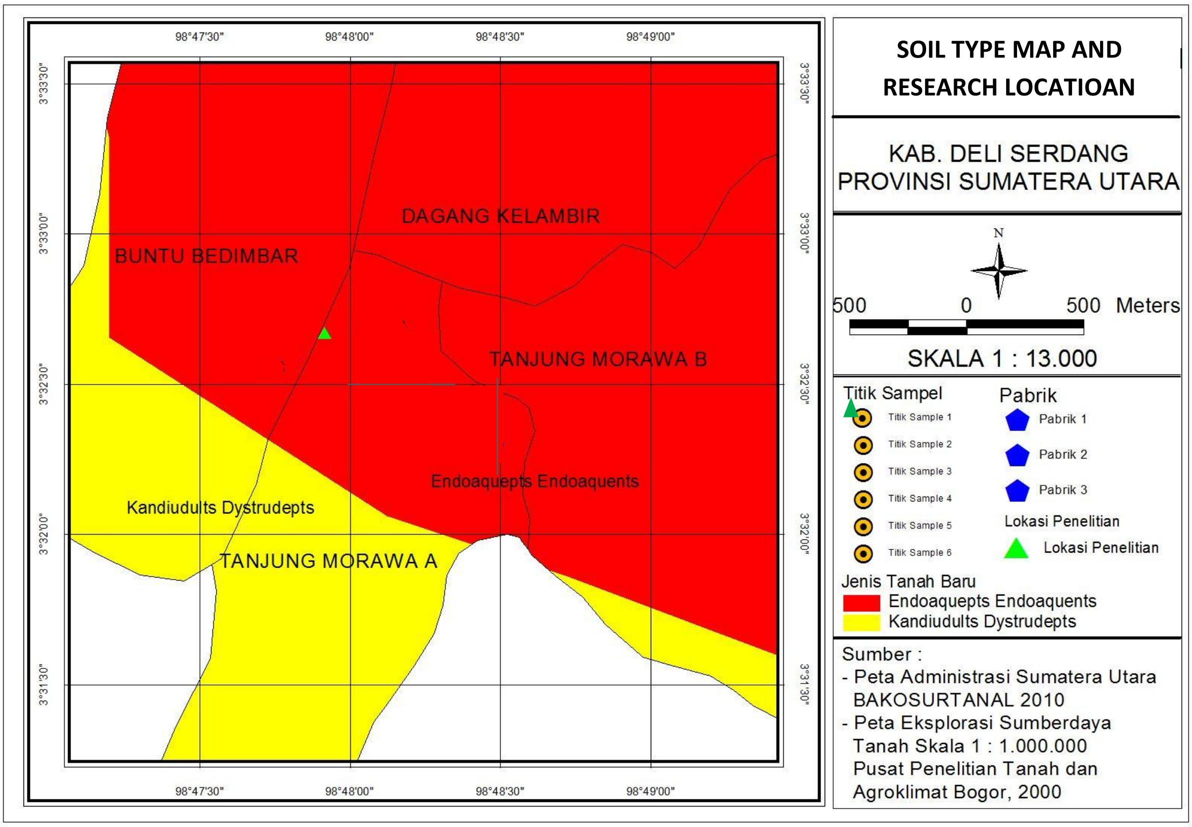

Figure 1 – Soil type map and research location

RESULTS AND DISCUSSION

The application of biochar and azolla had no significant effect on changes in soil pH in Pb-contaminated rice fields (Table 1). Provision of biochar tended to increase soil pH even though it was not statistically significant and the highest pH was in the rice husk biochar treatment at 6.69 and the lowest was in the control at 6.67.

The application of azolla had no significant effect with the highest pH in the treatment of *Azolla pinnata* (A1) at 6.69 which was not significantly different from the control and the lowest was in the treatment of Azolla mycrophylla (A2) at 6.66.

Table 1 – Application biochar and azolla on Soil pH in Soil Pb contaminated

Treatments	A0 (With out Azolla)	A1 (*Azolla pinnata*)	A2 (*Azolla microphylla*)	Average
B0 (With out Biochar)	6,68	6,68	6,65	6,67
B1 (Husk Biochar)	6,70	6,70	6,68	6,69
Average	6,69	6,69	6,66	20,04

The interaction of biochar and azolla had no significant effect on changes in soil pH, with the highest value on the interaction of rice husk biochar and *azolla mycrophylla* (B1A2), valued at 6.68 and the lowest value on the treatment of rice husk biochar and *Azolla pinnata* (B1A1) at 6, 70 and the two were not significantly different from the controls. Provision of biochar tends to increase the pH due to the presence of alkaline cations which give a liming effect but this property is reduced due to the polarity of the water which attracts each other towards two different poles so that the more water supplied will have an effect on pH neutralization (Hillel, 1980).

The application of biochar and azolla in general had a significant effect on soil organic carbon content in Pb-polluted rice fields (Table 2). The application of biochar tended to increase soil organic carbon although statistically it had no significant effect, giving biochar increased organic carbon from 1.60 (control) to 2.02 in the rice husk biochar treatment (B1).

Giving Azolla is a very real effect on improving soil organic carbon, with the highest value in the treatment of *Azolla microphylla* (A2) amounting to 2.30 ppm, and the lowest in treatment *Azolla pinnata* (A1) worth 1.49 ppm.

Table 2 – Application biochar and azolla on Soil Carbon Concentration in Soil Pb contaminated (%)

Treatments	A0 (With out Azolla)	A1 (*Azolla pinnata*)	A2 (*Azolla microphylla*)	Average
B0 (With our Biochar)	1,36	1,25	2,20	1,60
B1 (Husk Biochar)	1,90	1,74	2,42	2,02
Average	1,62a	1,49a	2,30b	1,81

Note: The numbers followed by the same letter are not significantly different based on the DMRT test at the 5% level.

Interaction biochar and Azolla provide no real influence on increasing the organic content of the soil, with the highest value on the interaction biochar rice husks and *Azolla microphylla* (B1A2) worth of 2.42 ppm and the lowest value in the treatment of rice hull biochar and *Azolla pinnata* (B1A1) worth 1, 74 ppm.

Azolla microphylla has the ability to replicate a 2-3 fold in one week, and Azolla also has a high adaptability so that with this capability could potentially contribute *Azolla microphylla* organic matter in the soil (Arora and Singh 2002; Hidayat et al 2017).

The application of biochar and azolla had no significant effect on increasing the total Pb of soil in Pb-polluted rice fields (Table 3). The application of biochar tended to reduce the total soil Pb although statistically it had no significant effect, giving biochar reduced the total soil Pb from 63.68 ppm (control) to 63.06 ppm in the rice husk biochar treatment (B1).

The provision of *Azolla microphylla* reduced the total Pb by 3.31 ppm compared to the control on Pb contaminated land although it was not statistically significant, from the value of 64.15 ppm in the control to 61.02 ppm in the rice husk biochar treatment, and giving *Azolla pinnata* increased the total Pb value. amounting to 0.79 ppm although statistically not significantly different.

The interaction of biochar and Azolla had no significant effect on the total soil Pb content, with the highest value on the interaction between rice husk biochar and *Azolla pinnata* (B1A1) at 67.61 ppm and the lowest value on the treatment of rice husk biochar and *Azolla microphylla* (B1A2) at 61, 97.

Table 3 – Application biochar and azolla on Pb- Total Concentration in Soil Pb contaminated (ppm)

Treatments	A0 (With out Azolla)	A1 (*Azolla pinnata*)	A2 (*Azolla microphylla*)	Average
B0 (With out Biochar)	68,69	62,28	60,07	63,68
B1 (Husk Biochar)	59,62	67,61	61,97	63,06
Average	64,15	64,94	61,02	63,37

Preparation of biochar in the pyrolysis process uses high temperatures and lead Pb in the materials will evaporate, hence the process does not contribute to the material biochar Pb, Pb evaporation temperature is 300-400 0C and then form a lead oxide (Palar, 1994)

Giving biochar and Azolla significant effect on the decrease in available soil Pb in paddy fields contaminated with Pb (Table 4), the provision of biochar lower the available soil Pb from 29.05 ppm (control) to 25.18 ppm on rice husk biochar treatment (B1) with a decrease of 3.87 ppm.

Azolla application had significant effect on the reduction of Pb available in Pb contaminated paddy fields, with the lowest value in the treatment of *Azolla microphylla* (A2) amounting to 23.34 ppm and the highest in the treatment of *Azolla pinnata* worth of 29.32 ppm and was not significantly different from controls.

Interaction biochar and Azolla give real influence on the decrease in available Pb in paddy fields contaminated soil Pb, with the highest available value in the treatment Pb Biochar rice husks and *Azolla pinnata* (B1A1) amounting to 27.91 ppm and Pb values at the lowest available biochar treatment chaff rice and *Azolla microphylla* (B1A2) valued at 21.55ppm.

Table 4 – Application biochar and azolla on Pb-Available Concentration in Soil Pb contaminated (ppm)

Treatments	A0 (With out Azolla)	A1 (*Azolla pinnata*)	A2 (*Azolla microphylla*)	Average
B0 (With out Biochar)	31,30	30,72	25,13	29,05b
B1 (Husk Biochar)	26,09	27,91	21,55	25,18a
Average	28,70b	29,32b	23,34a	27,12

Note: The numbers followed by the same letter are not significantly different based on the DMRT test at the 5% level.

The ability of biochar in reducing Pb available relating to the number of exchangeable base cations and biochar properties similar to organic material which has a variable payload acid and organic acid that can adsorb Pb available land becomes unavailable (Havlin et al, 2005).

The provision of Biochar and Azolla in general had a significant effect on increasing the production of Pb contaminated lowland rice in the field (Table 5). Application of the biochar increase rice production of 6.56 tons / ha in the control treatment into biochar 6.81 on rice husk treatment, although not statistically significantly different.

Table 5 – Application biochar and azolla on Pb- Available Concentration in Soil Pb contaminated (Tonnes/ha)

Teratments	A0 (With out Azolla)	A1 (*Azolla pinnata*)	A2 (*Azolla microphylla*)	Average
B0 (With out Biochar)	6,35	6,53	6,81	6,56
B1 (Husk Biochar)	6,55	6,50	7,40	6,81
Average	6,45a	6,51a	7,10b	6,69

Note: The numbers followed by the same letter are not significantly different based on the DMRT test at the 5% level.

The application of azolla increased the productivity of Pb contaminated land significantly, with the highest productivity in the *Azolla microphylla* (A2) treatment at 7.10 tons / Ha and the lowest in the control treatment with the value of 6.45 tons / Ha which was not significantly different from the treatment giving *Azolla pinnata* of 6.51, The production of *Azolla microphylla* increased by 10% when compared to controls.

The highest increase in production was found in the interaction treatment of rice husk biochar and *Azolla microphylla* from 6.35 tonnes / ha in the control to 7.40 tonnes / ha, up 16.53% and this was very spectacular for the first planting year.

Azolla's ability to increase rice production has long been known (Yadav et al., 2014), but the ability of azolla to increase rice production in polluted land is something very new, this is because azolla is a hyper accumulator plant that has Very high ability to absorb heavy metals without interfering with the physiological process, Hidayat (2011) said that azolla can accumulate 18 times higher than that in the soil, this ability is because there is a special

protein, namely pythochelatin which plays a role in metal uptake and is stored in special vacuoles so that does not affect the ability of azolla to fix N (Benaroya et al., 2004).

Giving biochar and Azolla generally give impairment Pb concentration in the husk, although not statistically (Table 6). Provision of rice husk biochar reduces the concentration of Pb in rice husks in Pb contaminated rice fields. The lowest concentration value in the rice husk biochar treatment was 2.13 ppm, down 0.03 ppm compared to the treatment without biochar.

Table 6 – Application biochar and azolla on Lead Concentration in rice Husk on Soil Pb contaminated (Tonnes/ha)

Treatments	A0 (With out Azolla)	A1 (*Azolla pinnata*)	A2 (*Azolla microphylla*)	Average
B0 (With out Biochar)	2,43	2,33	1,71	2,16
B1 (Husk Biochar)	2,14	2,53	1,73	2,13
Average	2,29	2,43	1,72	2,14

Giving Azolla shows a decrease in Pb concentration value of rice husk yields in Pb contaminated soil. The value of the lowest concentration showed in application of the *Azolla microphylla* valued at 1.72 ppm and no significant difference in treatment *Azolla pinnata* (2.43 ppm) and without Azolla (2,29ppm).

The application of rice husk biochar and Azolla in general significantly reduced Pb concentrations in rice harvested in Pb contaminated land (Table 7). The provision of rice husk biochar reduces the Pb concentration in the rice harvested in Pb polluted land, although it is not statistically significant. The lowest concentration was in the rice husk biochar treatment at 13.18 ppm and the highest was in the treatment without Biochar at 14.06.

Table 7 – Application biochar and azolla on Lead Concentration in rice harvested on soil Pb contaminated (Tonnes/ha)

Treatments	A0 (With out Azolla)	A1 (*Azolla pinnata*)	A2 (*Azolla microphylla*)	Average
B0 (With out Biochar)	16,28	15,32	10,59	14,06
B1 (Husk Biochar)	14,78	15,64	9,13	13,18
Average	15,53A	15,48A	9,86B	13,62

Note: The numbers followed by the same letter are not significantly different based on the DMRT test at the 5% level.

Application of Azolla on paddy soil contaminated showed a decrease in concentration of Pb in rice is very real. The lowest Pb concentration was found in the treatment of *Azolla microphylla* with a value of 9.86 ppm, which was significantly different from that of *Azolla pinnata* (15.48 ppm) and without Azolla.

The lowest decrease in Pb concentration in rice was found in the interaction treatment between biochar husk and *Azolla microphylla* from 16, 28% in the control to 9.13%, which was a decrease of 43.91% and this was very spectacular with heterogeneous field conditions.

Azolla mycrophylla's high ability is due to its adaptability and growth rate which is very fast compared to *Azolla pinnata* (Arora and Singh, 2002; Arora et al 2005), Azolla is able to replicate 2-3 times a week and a very high bioaccumulation capacity of 18 meaning that Azolla mycrophylla absorbs 18 times the concentration more than that in solution (Hidayat, 2011.

CONCLUSION

The application of biochar and Azolla to Pb contaminated land increases the productivity of Pb-contaminated rice fields by stabilizing the pH, increasing the soil's organic C content, stabilizing total Pb, reducing available Pb of soil, filled grain, 1000 grain weight, and reducing the Pb content of husk and paddy rice grain. The provision of Biochar rice husk and *Azolla microphylla* produced the highest production valued at 7.40 tonnes / ha, up 16.54% and *Azolla microphylla* significantly increased production to 7.10 tonnes / ha, up

11.81% compared to control treatment. The administration of rice husk biochar and *Azolla microphylla* resulted in the lowest Pb concentration in rice from 16.28% in the control to 9.13% down 43.91% from the administration. *Azolla microphylla* was able to reduce the Pb concentration significantly to a concentration of 9.86% down 39, 43%.

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