Leachability and Plant Absorption of Heavy Metals From Sewage Sludge Biochar

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Introduction and Objective

The production of sewage sludge has been increasing along with the increasing sewage system coverage[1]. However, securing landfill spaces is becoming a serious problem. Carbonizing sewage sludge may alleviate the problem. Sewage sludge biochar (SSB) is expected to provide essential plant nutrients when applied to soils. However, soil pollution by heavy metals from SSB application may also occur but its dynamics is not fully understood. In this study, effects of SSB application to soil on leachability of heavy metals (Cu, Zn, Pb, and Cd) from SSB and their adsorption by plants were investigated.

Materials and Methods

A soil used in this study was a forest Andisol (<2 mm) sampled in Tokyo. SSB produced at high temperature (800°C; SSB-H) and low temperature (300°C; SSB-L) were sieved to 2-5 mm. A bioassay experiment was conducted using Japanese mustard spinach (*Brassica rapa var.*) and common bean (*Phaseolus vulgaris*).

Bioassay experiment

SSB-H and SSB-L were applied to soil at rates (v/v) of 0%, 25%, 50%, and 75% and 0%, 5%, 15%, and 25%, respectively, in 1 L pot. Chemical fertilizer was applied in each pot at recommended rates for each plant. Mustard spinach and common bean were harvested 46 and 66 days after seeding.

Analysis

- Soil and SSB
  pH, TC, TN,
  total Cu, Zn, Cd, and Pb,
  0.1 M HCl extractable-
  Cu, Zn, Cd, and Pb

Table.1 pH and heavy metals in soil and SSB

	pH	Cu	Zn	Cd	Pb
		μg g^{-1}			
Andisol	7.10	25.1	43.3	4.85	11.7
SSB-H	6.61	346	455	1.36	13
SSB-L	5.60	68.7	237	1.48	12.5

- Plants in aboveground and belowground parts
  Dry matter yield, total Cu, Zn, Cd, and Pb

Heavy metals in samples were analyzed by ICP (Shimazu, ICPS-700 ver.2.1)

Plants Dry Matter Yield

Aboveground

Dry matter yield of the aboveground part of both plants with 5% SSB-L rate was significantly increased compared with those of control and other rates of SSB-L. Dry matter decreased with increasing application rates of SSB-H.

Belowground

Dry matter yield of the belowground part of both plants decreased with increasing application rates of SSB-H.

Decreasing dry matter yield was probably because of lack of soil volume in the pot with increasing application rate of SSB-H.

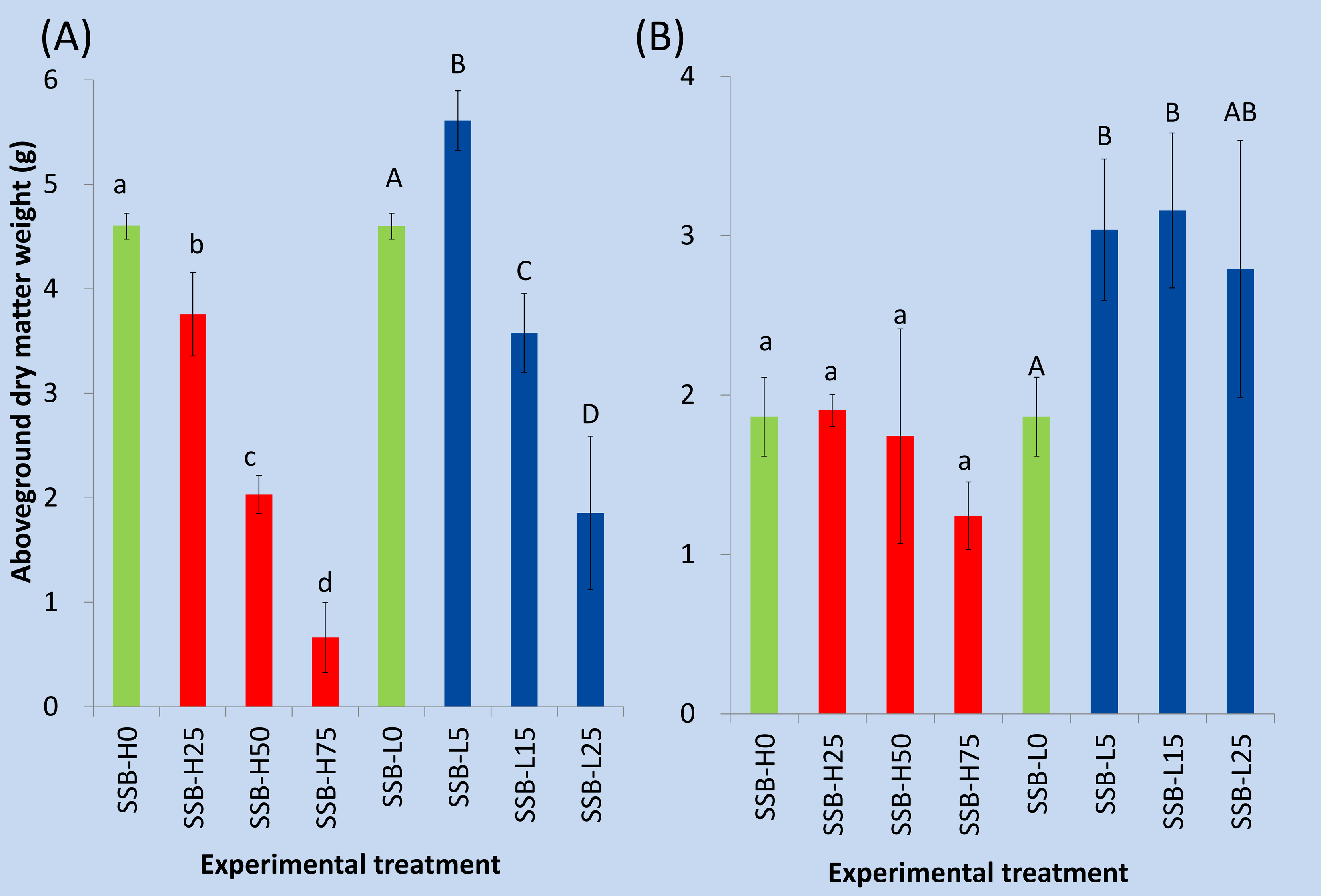

Fig.1. Spinach (A) and common bean (B) dry matter yield in aboveground part. Error bars are standard deviations. Same letters indicate that there were no significant differences in Fisher's multiple comparison method at $p<0.05$.

Heavy Metal Concentrations

Plants

Heavy metal concentrations of the belowground part were higher than those of the aboveground part of both plants. However, none of treatment caused plants to show symptoms of excess absorption of heavy metals because of root's biochemical mechanism for heavy metal tolerance.

SSB

Heavy metal left in SSB decreased after the bioassay experiment, implying heavy metals leaching from SSB.

Soil

Leachability of heavy metals from SSB to soil was confirmed by difference of 0.1 M HCl-extractable heavy metals in soil and the total amounts of heavy metals in SSB analyzed before and after the bioassay experiment.

Cu and Zn concentrations in plants at 75% SSB-H rate were higher than those at other rates, respectively.

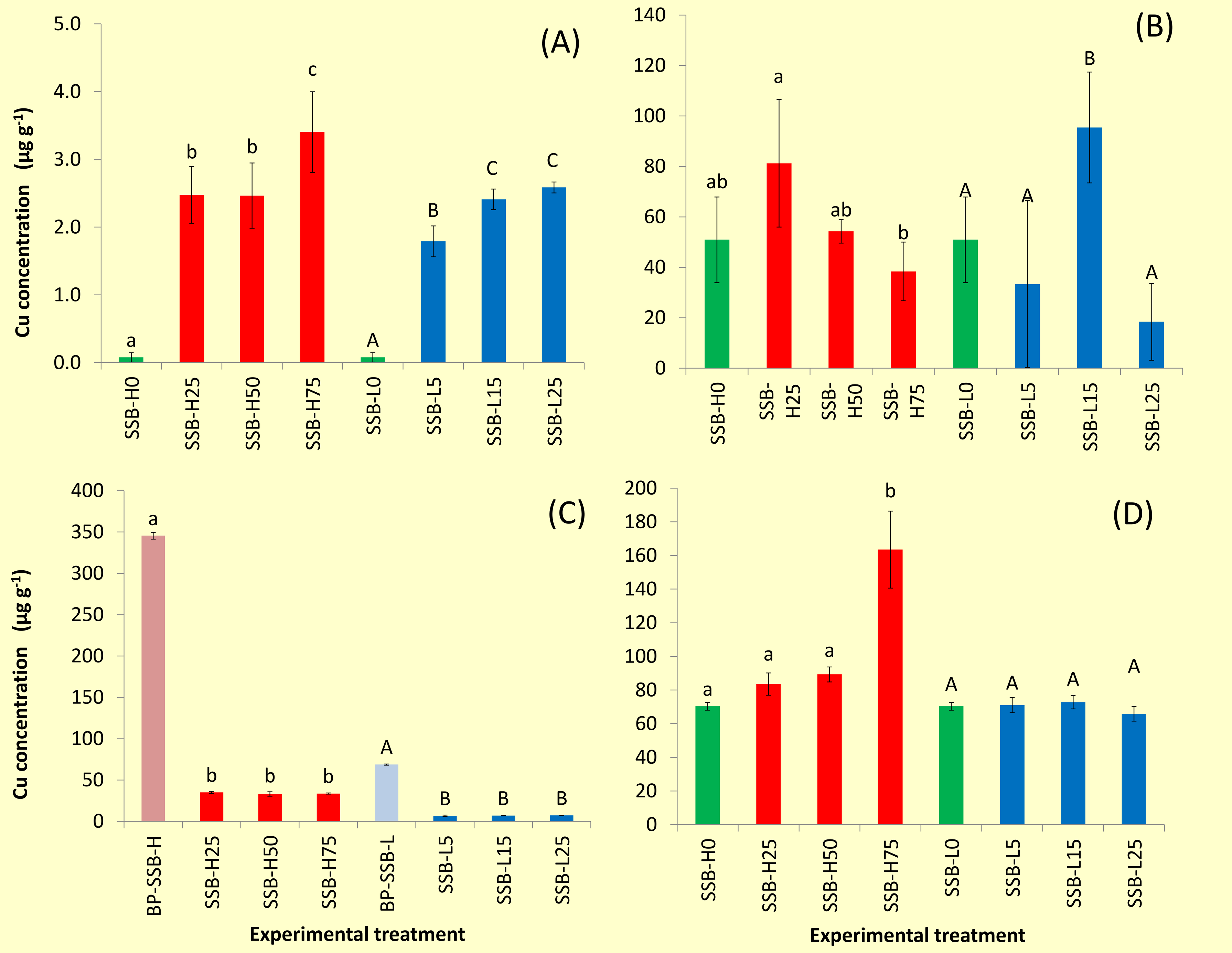

Fig.2. Cu concentration in (A) spinach above ground, (B) spinach belowground, (c) SSB before and after bioassay test, and (D) soil after bioassay test. Error bars are standard deviations. Same letters indicate that there were no significant differences in Fisher's multiple comparison method at $p<0.05$.

0.1 M HCl extractable heavy metals

After cultivation, heavy metals in soils were extracted with 0.1 M HCl. None of heavy metals surpassed the environmental threshold levels set by the Japanese Environmental Agency. Therefore, the application rates of both SSB types used in this study would not impose environmental pollution in the soil.

Table. 2 0.1 M HCl extractable heavy metal concentrations in soils after mustard spinach was cultivated and environmental threshold

	Cu	Zn	Cd	Pb
	mg kg^{-1}		mg L^{-1}	
Environmental threshold	125	125	0.01	0.01
SSB-H 25%	0.30	3.95	0.00	0.00
SSB-H 50%	0.40	4.47	0.00	0.00
SSB-H 75%	1.38	7.61	0.00	0.00
SSB-L 5%	0.32	3.71	0.00	0.00
SSB-L 15%	0.30	4.18	0.00	0.00
SSB-L 25%	0.14	2.80	0.00	0.00

Conclusions

(1) The effect of SSB application on the plant growth was dependent on the type and rate of SSB, however negative effect of heavy metals from SSB on the growth may be insignificant within the application rates used in this study.
(2) It appeared that the majority of heavy metals studied leached from SSB but were adsorbed onto soil in stable forms.
(3) It is suggested that long-term dynamics and transformation over time of heavy metals when SSB is applied to soil need to be investigated.

Reference
1) Japan Sewage Works Association. "Recycling rate and the amount of sewage sludge." 2008. http://www.jswa.jp/data-room/data.html. (Referenced 2012.7.26)