Kerr Center for
Sustainable Agriculture
P.O. Box 588
Poteau, OK 74953
Phone: 918.647.9123
Fax: 918.647.8712
mailbox@kerrcenter.com
www.kerrcenter.com

The Effects of Added Mineral Salts on Biochar Yield Using a Two-Barrel Nested Retort

by Jonathan Pollnow, Student Intern 2013
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Our investigations of biochar during the spring and summer of 2013 taught us that the percentages of cellulose, hemicellulose and lignin in the feedstock are major determinants of the quantity and quality of char produced in our retort [1]. A further determinant of interest is ash content - the mineral nutrient salts contained in the feedstock. Different ash elements can influence the production of more or less volatile gases, affecting the yield of char.

One study (Williams and Horne 1994) looked at the effects a number of mineral salts have on pure cellulose during pyrolysis. This study suggested that char yields could be boosted with the addition of certain mineral salts because of a catalytic effect that lowers the temperature at which cellulose starts to pyrolyze and hinders the development of volatile gases.

By contrast, other salts *encourage* the formation of volatile gases, which is desirable when the primary goal is gasification or the production of other biofuels and chemicals. But since our primary interest is the production of more biochar, we are most interested in those mineral salts that *hinder* the release of volatiles. Two of the char-boosting salts in the cited study, sodium chloride (NaCl) and copper sulfate (CuSO4), are inexpensive and readily available.

Procedures

We chose to use corn cobs for our experiment. According to the Phyllis2 biomass database, corn cobs have low ash content, and should show a strong change in yield and other measurements with the addition of a salt. The cobs were weighed into four sample groups: 1) control A, 2) NaCl-treated, 3) control B, 4) CuSO4-treated. (Controls were identically treated, but were selected to have sample weights as near as possible to their respective treatment group in order to reduce error from significant extra or lesser mass.)

All samples were soaked in 80 ml of dechlorinated water. For the salt treatments, we dissolved in the dechlorinated water an amount of salt equal to 1% of the mass of the feedstock. We chose to use an aqueous solution of the salts to better penetrate the feedstock tissues and stick to its surfaces.

After soaking, the feedstock cobs were allowed to dry overnight. The dried samples were separately sealed in closed metal containers and placed in the larger main feedstock barrel of the retort. The retort was fired and heated to a minimum of 350° C (662° F) in the charge container. Pre- and post-firing volumes were determined by measuring the length and width of each cob and calculating volume according to the formula for the volume of a cylinder *($V = r^2h$)*.

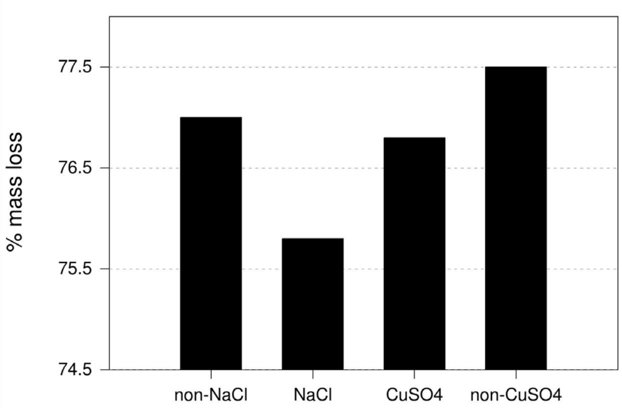

FIGURE 1. Salt-treated cobs lost slightly less mass than untreated cobs.

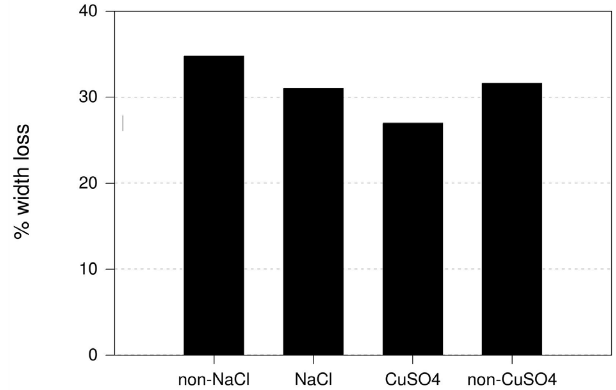

FIGURE 3. Salt-treated cobs lost less width than the untreated cobs.

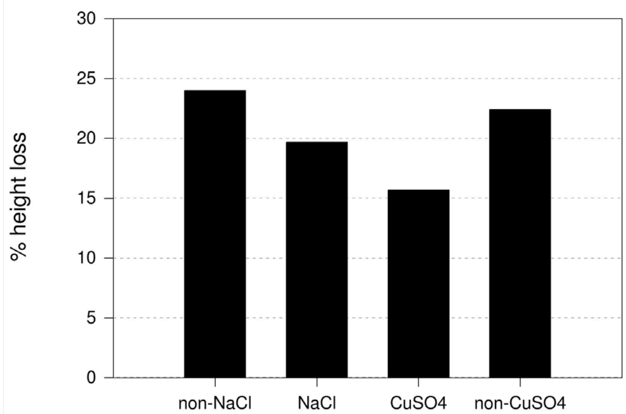

FIGURE 2. Salt-treated cobs lost less height than the untreated cobs.

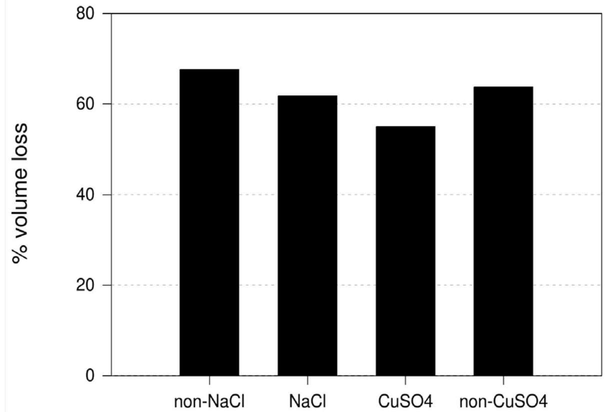

FIGURE 4. Overall, the salt-treated cobs lost less of their volume than the untreated cobs.

Results and Discussion

As expected, cobs treated with NaCl and CuSO4 lost slightly less mass than their untreated counterparts. We might assume that the similarities have something to do with the salt-treated cobs starting pyrolysis earlier. The difference in volume between feedstocks was more dramatic, and suggests that considerably more of the cellulose is indeed being converted to biochar instead of gassing off.

It is possible that crushing or grinding feedstocks to smaller particle sizes would enhance the differences, because more salts would be retained and in contact with the cellulose. Simple additions of a tiny amount of NaCl or CuSO4 to a feedstock before pyrolysis diverts more of the feedstock into char, resulting in less production of possible air pollutants and greenhouse gases.

Further research is advisable to assess agronomically safe levels for added salts in the making of biochar, and tailoring recommendations to different regions. Additional salts may be no problem in the humid East, but worsen soil salt accumulation in the arid West.

Notes

1. See “2013 Biochar Feedstock Research Using a Two-Barrel Nested Retort,” also by Jon Pollnow, on the Kerr Center website.

References

Phyllis2, database for biomass and waste. www.ecn.nl/phyllis2. Energy research Centre of the Netherlands.

Williams, P. T. and Horne, P. A. 1994. The role of metal salts in the pyrolysis of biomass. *Renewable Energy* 4:1-13.