Hydrothermal Carbonization of Waste Paper

Beth Quattlebaum

Senior Undergraduate Research Assistant, Department of Civil and Environmental Engineering, University of South Carolina, Columbia, SC 29208

There are many components of waste that enter a municipal solid waste (MSW) landfill. One major component of that waste stream is paper. This research project involves the hydrothermal carbonization of four paper types commonly discarded and sent to MSW landfills. Hydrothermal carbonization (HTC) is a unique waste management process which involves carbonization of biomass in water under autogenous pressure at temperatures below the critical point of water ($<374^{o}C$). A solid, carbon-rich material, called hydrochar, results from this process. The carbonization of paper, as well as other waste materials, has many significant potential advantages. The two main concepts relating to using HTC for waste management include carbon sequestration and the potential for providing a sustainable energy supply for the future. The utilization of HTC to promote carbon sequestration and energy generation would be a significant milestone in establishing a more sustainable approach for managing wastes and energy. These advantages are attributed to not producing significant carbon dioxide because of carbon being stored within the hydrochar, the chemical structure of the hydrochar produced imitating natural coal, and the dramatic reduction in time required for biological processes to take place. With carbon being stored in the hydrochar, greenhouse gas emissions could be considerably reduced. In exploring the use of HTC for waste management, it is necessary to understand how different types of paper influence reaction rates, carbon distribution, and hydrochar energy content. The use of HTC as an alternative waste management strategy may change how we manage our waste.

Four common paper types found in a landfill include printed office paper, non-printed office paper, newspaper, and cardboard. The carbonization of these four paper types was compared to determine whether there was any significant difference between the paper types on the overall reaction that takes place within the HTC reactor. The experiments were conducted in 160-mL tubular steel reactors equipped with gas sampling valves. The reactors were first loaded with 8 grams of paper and 32 grams of water, and subsequently heated at a constant temperature of $250^{o}C$ over time periods ranging from 2 hours to 96 hours. After the HTC reactors were cooled, the liquid, solid, and gas properties were examined. Liquid properties measured include: pH, conductivity, chemical oxygen demand, total organic carbon, and biochemical oxygen demand. The solid properties measured were carbon content, energy content, and hydrochar yield. From the gas collected the volumes and compositions were recorded. The tests were run in four different cycles (in duplicate) with each cycle containing one paper type.

Experimental results show that the hydrochar yield decreases with time, while energy content increases with time. It has also been observed that the majority of carbon is being stored within the hydrochar, which promotes carbon sequestration. A more detailed explanation of these results will be presented.