Charcoals: An Electron Microscopy Study

By Josh Kearns and Detlef Knappe, with SEM images by Carl Saquing

August 2008

This paper presents images from an electron microscopy study of charcoal and biochar materials.

Aqueous Solutions would like to thank Dr. Carl Saquing, PhD for his diligent work collecting the superb scanning electron microscope images presented here, and Professor Detlef Knappe for providing mentorship and access to laboratory facilities and research materials.

Charcoal Filtration

Charcoal has been used for water purification for centuries, dating back as far as ancient Egypt and India. Many charcoal materials exhibit a high molecular surface area per volume: for example, one gram of industrially produced activated carbon may have a surface area of 400 – 1500 m^2 (a football field is about 5000 m^2). Non-activated charcoals can range from 5 – 500 m^2/g. Non-polar organic molecules dissolved in water are strongly attracted to charcoal surfaces and bind due to electrostatic interactions – this gives charcoal materials their utility as water filtration media.

Charcoal Making

Charcoal is made by pyrolizing (heating in an oxygen-poor atmosphere) wood or other organic matter such as coconut or rice husks, nut hulls, peat, etc. in earthen kilns, brick ovens, or underground pits. “Activation” of charcoal typically refers to physical or chemical processes designed to increase the reactive surface area of the carbon. Industrial activation processes may use chemicals and/or steam to enhance surface area, although simply heating the material to sufficient temperatures can produce a char with significantly enhanced molecular surface area.

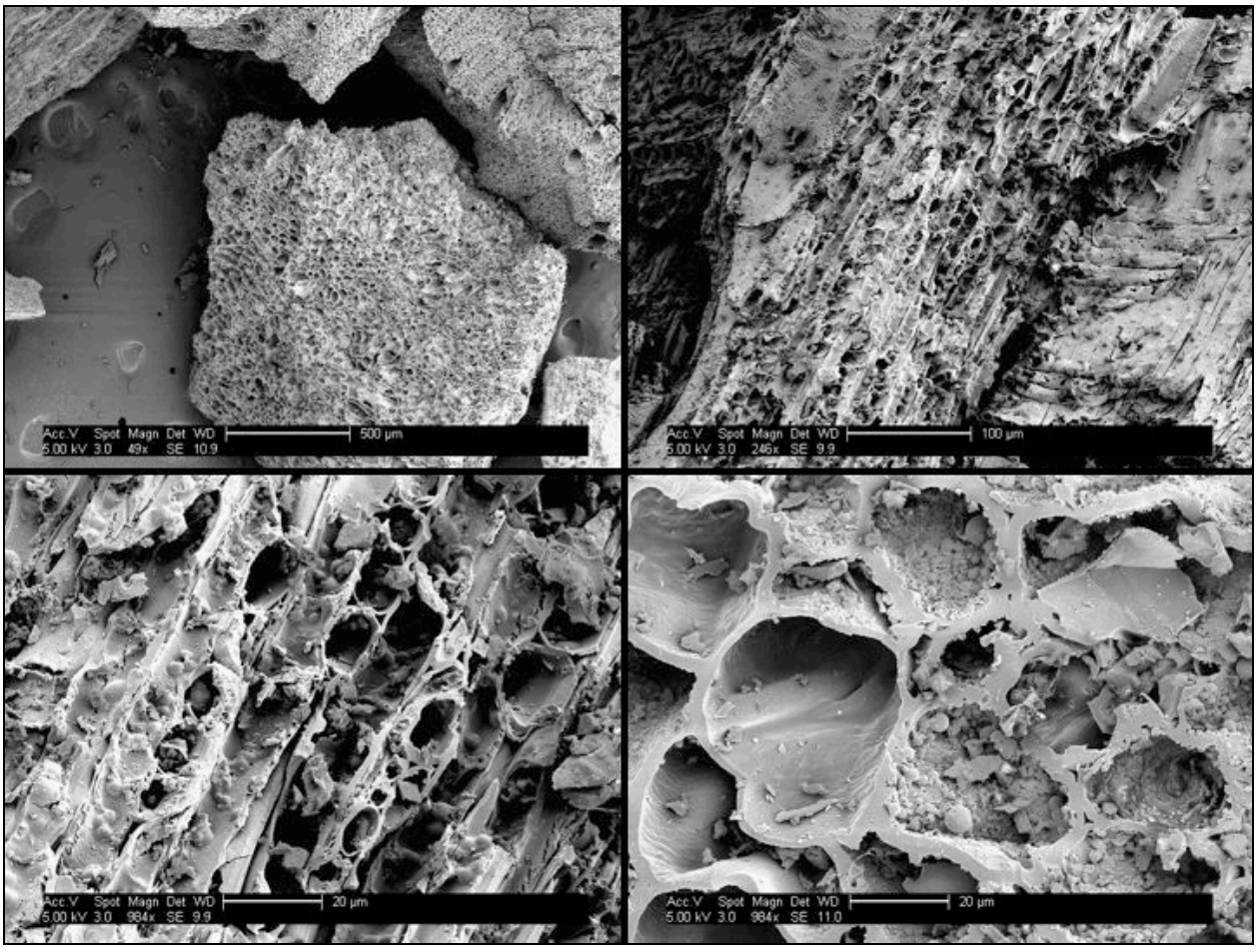
Earthen kilns near Mae Taeng, Chiang Mai Province, Thailand. Charcoal can be purchased in bulk for 2 - 10 Baht per kilogram ($0.03 – $0.08 per pound).

An underground pit kiln for clandestine charcoal making (using illegally logged wood) located in the national forest in Chiang Mai province, Thailand.

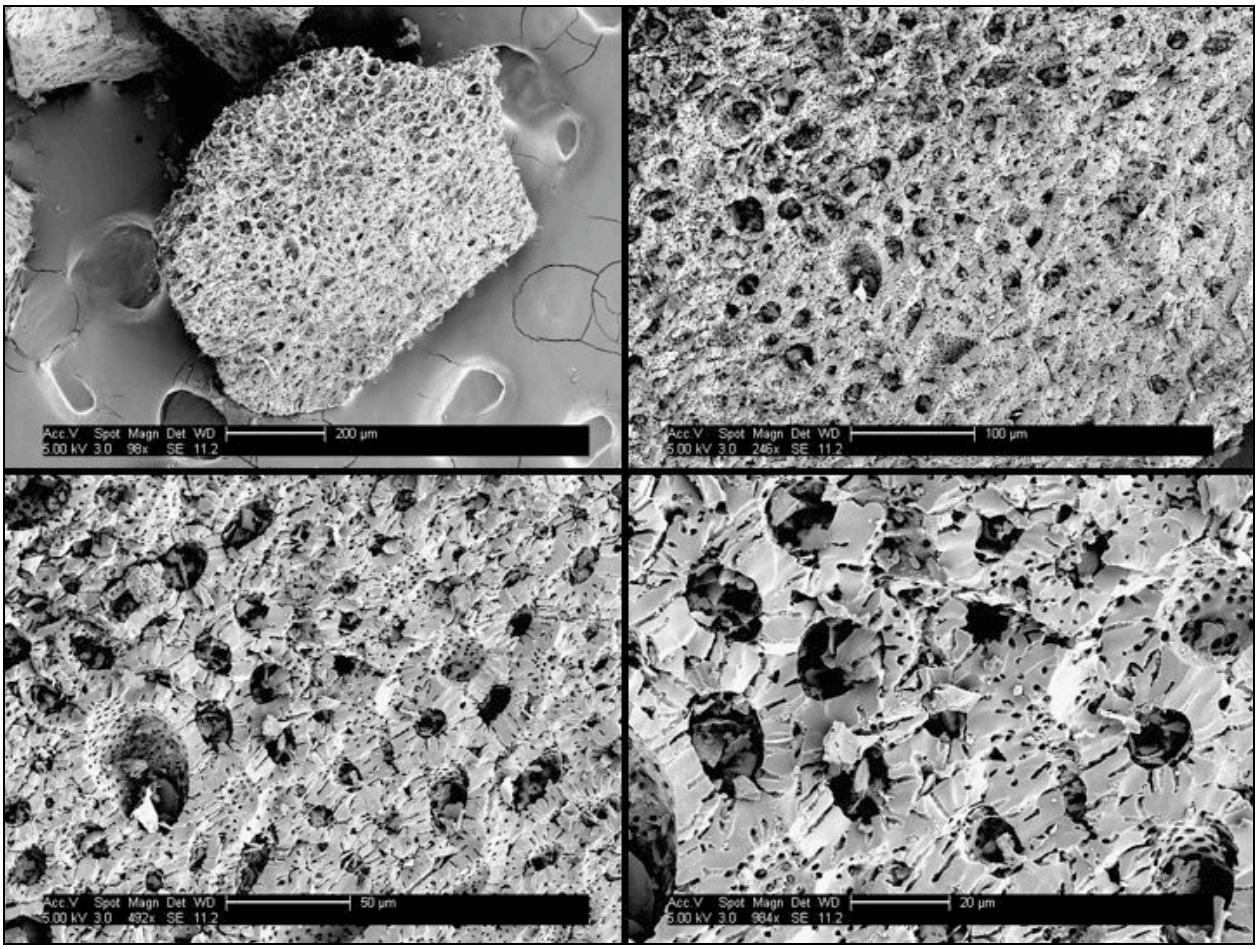
Electron Microscope Images

Aqueous Solutions is currently conducting experiments to characterize a variety of locally produced charcoal and biochar materials and assess their capacity as water filtration media as compared with high-grade industrial materials. An aspect of this research program uses scanning electron microscopy (SEM) to investigate surface morphology and macro-pore structure of chars made from a variety of organic feedstocks and over a range of pyrolysis conditions (temperature, atmospheric composition, etc.).

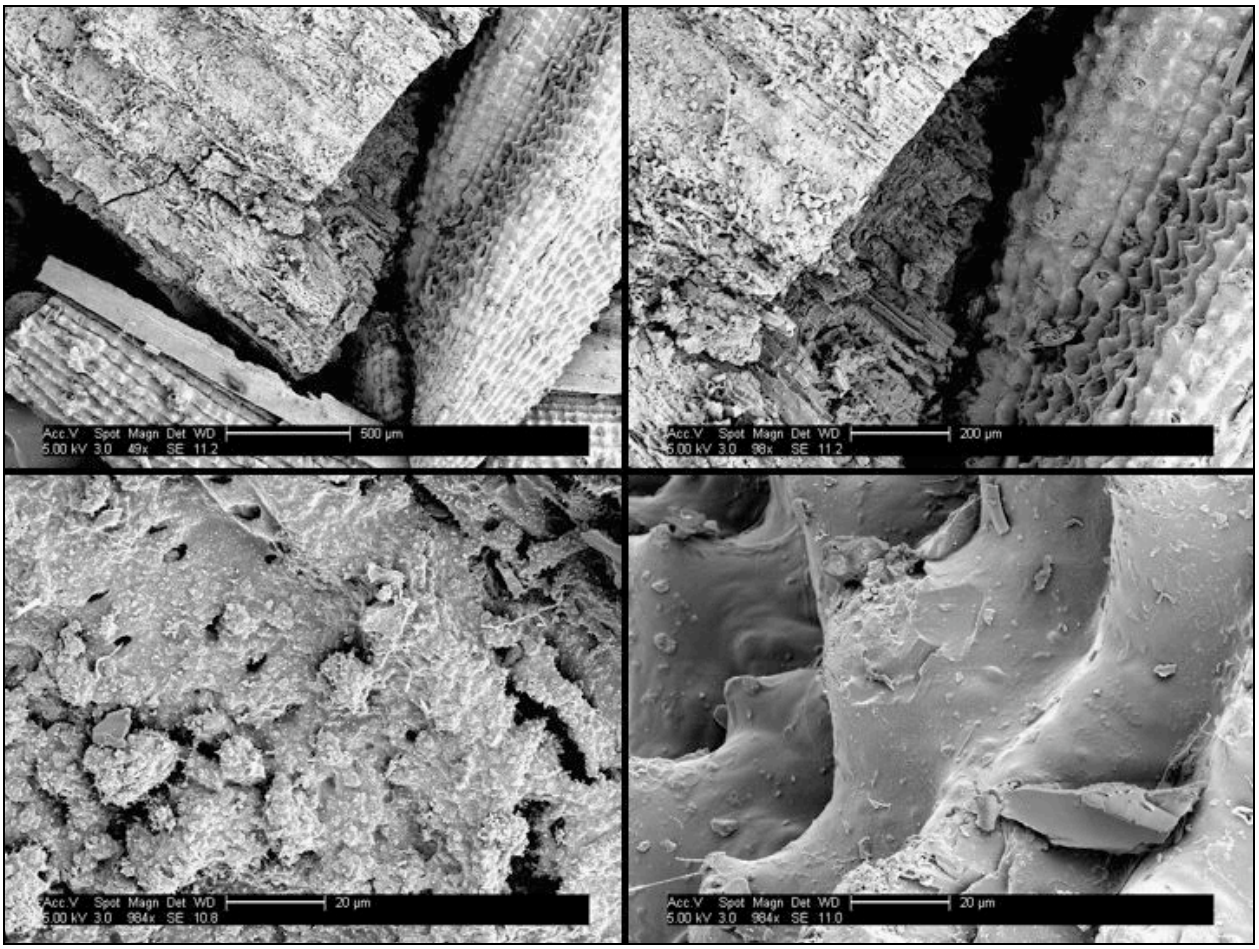
The SEM images just below are of charcoal made from longan wood (*Dimocarpus longan*).[i] These fruit trees are very common throughout southern China, southeast Asia, and the region around Pun Pun Farm in northern Thailand. Longan orchards are often propagated by air-layering techniques, and the trees do not develop a strong taproot. They must be pruned often in order to protect the trees from storm damage – it's therefore a common practice to make charcoal from the abundant longan wood prunings.



The next set of SEM images show charcoal made from the husks of young coconut.



The SEM image below shows charcoal made from rice husks. This material represents the low-quality end of charcoals from a water filtration perspective, because of its naturally high ash content from the silica and minerals that make up the husk. Also, rice husk charcoal is not made in a kiln - husks are just piled onto a fire and allowed to smolder. So the pyrolysis temperature is relatively low and oxygen is not well excluded - thus rice husk charcoal does not develop significant porosity and molecular surface area necessary for effective water filtration.



The images on the left show the underside of a husk. The images on the right the outer side of the husk – the differences in surface morphology of the char are very evident.

This document will be updated with more images as our studies continue.

For more information on pesticides and drinking water filtration using charcoal, see our website: ***aqsolutions.org***

[i] Wikipedia: http://en.wikipedia.org/wiki/Longan