Activated Carbon and Water Treatment

By Fred Reiff, PE

Drinking water treatment facilities employ a host of technologies to convert "raw" water from rivers, lakes and underground sources into safe, potable water. At the treatment plant, these technologies are applied in a particular order, known as a "treatment train," to produce water of optimum quality for the consumer. This article focuses on one of these technologies, adsorption with activated carbon, which removes unwanted substances from water in a purely physical way.

Activated carbon is used by water treatment facilities to help improve water quality. Many home water treatment devices also employ activated carbon, especially to help reduce water odor and taste.

What is activated carbon?

Imagine a substance that has an extremely high surface area per unit mass, a highly porous substance. One gram (or about ½ teaspoon) of activated carbon contains about 5,400 square feet of surface area! That's roughly twice the area of the average American home (see National Association of Home Builders website). That is a lot of "nooks and crannies," places where water contaminants can get stuck and "adsorbed" onto the carbon in response to attractive forces. In general, access to the surface area improves with decreasing carbon particle size, thereby increasing the adsorption rate.

Adsorption is not a misprint: it is different from ***absorption***. ***Adsorption*** occurs when atoms, ions or molecules from a gas, liquid or dissolved solid adhere to a surface.[1] When a substance is ***absorbed***, on the other hand, it fills the empty spaces inside a solid (imagine a completely saturated sponge). Adsorption is usually weak and reversible, but organic compounds with color, taste or odor—substances we prefer to exclude from our drinking water— tend to bind strongly to activated carbon.

Activated carbon can be prepared from many common substances that are high in carbon, and bituminous coal is a typical starting point. First, coal is heated in the absence of oxygen. It may then be exposed to other chemicals, such as argon and nitrogen, and heated again in the presence of steam and oxygen. The second heating process creates a pore structure that "activates" the carbon by greatly increasing the surface area of the carbon. A great environmental and economic advantage of activated carbon is that it is recyclable following a thermal treatment to drive off adsorbed compounds. That process is called reactivation.

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[1] In an aqueous medium a suspended particle can also be adsorbed, but it is one or more of the molecules in the particle that is attracted.

Activated carbon can be utilized in a granular (GAC) form placed in filter bed or media through which water passes or can be utilized in a powdered form (PAC) that is fed into the treatment train and removed along with other solids present in the water being treated.

Activated carbon and disinfection byproducts

In the 1970's, scientists began to identify low levels of unwanted compounds in drinking water known as disinfection byproducts (DBPs). DBPs are unintended products of chemical reactions between chemical disinfectants, including chlorine, that are added to destroy pathogens and naturally occurring organic matter in water. The discovery of these substances and studies of their health effects led to the regulation of the most commonly formed varieties of DBPs.

Since the 1970's researchers have identified treatment processes that minimize DBP formation that include:

- Prior to disinfection: Reducing the amount of naturally-occurring organics from the source water (DBP precursors)
- During disinfection: Changing the reaction conditions in the plant (pH and time of contact with disinfectants)
- After disinfection: Reducing the amount of DBPs that are formed after disinfection

In conclusion, adsorption with activated carbon is an efficient and useful technology—one of several in the water treatment toolbox that can be applied to help provide the best quality drinking water possible.

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