EPA Facts About
Activated Carbon Treatment

June 1992

What is activated carbon treatment?

The process of activated carbon treatment makes use of a particular physical attribute of the chemical carbon. Carbon has the ability to adsorb, or grab onto passing organic molecules and hold them in pores within the carbon granule. Organic molecules are those that contain carbon and are usually associated with natural processes. When a waste stream containing organic contaminants is pumped through a filter of carbon granules, a large portion of the contaminant becomes trapped in the pores. Essentially the same process is used in the filter of most household aquariums.

After a certain length of time, all the surface area inside the pores is used up and the filter is said to be saturated or spent. At this point, the carbon in the filter must be replaced or regenerated. This regeneration is usually accomplished by heating the carbon and passing an air stream through it. The heat loosens the organic molecules, and they are swept away by the air stream. The freed organic molecules are subsequently collected and treated or destroyed.

Most hazardous waste treatment applications use adsorption units that contain granular activated carbon (GAC). Figure 1 presents the essential parts of the GAC treatment method.

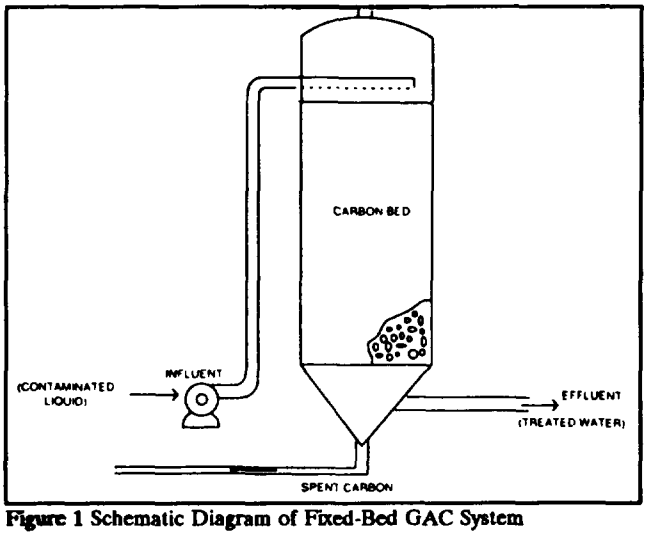

Figure 1 Schematic Diagram of Fixed-Bed GAC System

What is adsorption?

Adsorption is the adherence (ability to stick to) of one substance to the surface of another by physical or chemical processes. The treatment of waste streams using the adsorption process is essentially a method of transferring and concentrating the contaminants from the waste stream to another material. The most commonly used material is activated carbon in granule form.

Activated carbon granules are highly porous (full of holes). Adsorption takes place on the walls of these pores because of an imbalance of forces on the atoms of the walls. The adsorption of organic molecules serves to balance these forces.

Adsorption treatment usually involves pumping the waste stream through a container (normally columns) of activated carbon granules. Relatively large spaces between granules (voids) ensure that the waste stream is allowed to move through the column and contacts many granules. The treated waste stream leaves the column with reduced concentrations of contaminants. It can be directed into a series of these columns; each column removing more and more of the contaminant. Some duplication is built into the system to allow for some columns to be taken out of service while the activated carbon is replaced or regenerated. This allows the operation to proceed with minimal delays. The activated carbon in each column will eventually become saturated and can be disposed of in approved landfills, or regenerated as mentioned above.

What is the value of GAC?

Activated carbon is an effective and reliable means of removing organic contaminants. It is suitable for treating a wide range of organics over a broad concentration range. The use of several carbon adsorption columns at a site can provide considerable flexibility. Several columns can be arranged in series (one after the other) to increase the service life between regeneration of any particular column. They can also be arranged in parallel so that a maximum volume can be treated at any one time. The piping between columns would allow for one or more column to be taken out of service to be regenerated while the other columns continue to work.

The most obvious maintenance consideration associated with activated carbon is the regeneration of the saturated carbon for re-use. Regeneration must be performed for each column as it becomes saturated so that the carbon can be restored as close as possible to its original condition. If regeneration is not used, the carbon can be disposed of in an approved landfill. Most other operations and maintenance procedures are minimal for this technology if appropriate automatic controls have been installed.

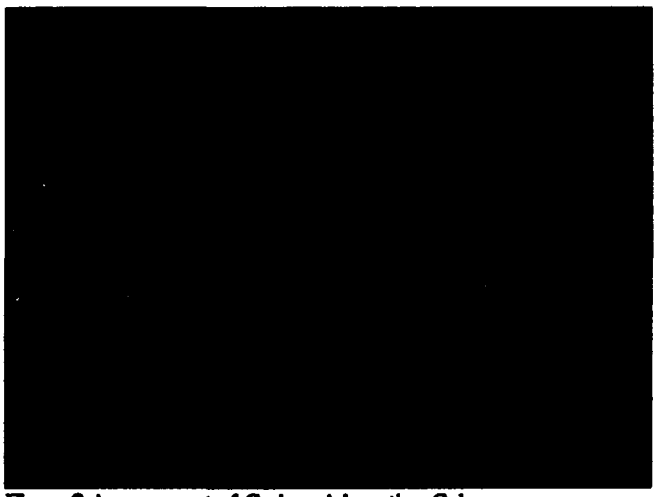

Figure 2 Arrangement of Carbon Adsorption Columns

What are the applications of granular activated carbon (GAC)?

Activated carbon is a well developed technology which is widely used in the treatment of hazardous waste streams. It is especially well suited for the removal of organic contaminants from liquid wastes.

Some metals and inorganic chemicals may also be removed from a waste stream with some success, including antimony, arsenic, bismuth, chromium, tin, silver, mercury, cobalt, zirconium, chlorine, bromine, and iodine.

Carbon adsorption is generally accepted for use in the control of volatile organic compounds (VOCs), hydrogen sulfide, and some radioactive elements such as iodine, krypton, and xenon. VOCs are organic compounds that evaporate rapidly when heated or disturbed in any way. The odor that surrounds us when we pump gasoline into the tank is a good example. Carbon adsorption can also be used to control sulfur oxides, nitrogen oxides, and carbon monoxide.

Carbon adsorption is widely used in industry for air pollution and odor control. Often these systems are operated in association with a recovery and re-use program for the contaminants.

Adsorption by activated carbon has a long history of use as a treatment for municipal, industrial and hazardous wastes. The relative effectiveness of carbon adsorption is related to the chemical composition and molecular structure of the contaminant.

What is the technology of GAC?

Carbon is an excellent adsorbent material because of its large porous surface area. This area is made up of many different surfaces which are highly attractive to many different kinds of contaminants. Regular carbon is made into activated carbon through a process that produces an extensive network of internal pores.

The process of adsorption takes place in three steps. First, the contaminant moves to the external surface of the activated carbon granules. It then moves deeper into the pore structure. Finally, a physical or chemical bond forms between the contaminant and the internal carbon surface.

What process residuals result from GAC?

The main residual produced from an activated carbon system is the spent carbon which contains the hazardous contaminants. When the carbon is regenerated, the contaminants are released from the carbon and must be recovered or destroyed. If the carbon cannot be economically regenerated, it must be treated and disposed of in an approved landfill.

For more information about Activated Carbon Treatment you may contact EPA at the following address:

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The information in this fact sheet was compiled from the EPA Engineering Bulletin: Granular Activated Carbon Treatment, October 1991