CARBONAIR

Carbonair Environmental Systems provides a wide selection of products services for the remediation of contaminated water, air, and soil. These environmental remediation technologies include carbon adsorption, packed tower air stripping, and low-profile air stripping. The following handout is to describe the fundamentals and applications of each remediation technology.

Carbon Adsorption

Adsorption is a process in which molecules of a liquid or gas are attached to and then held at the surface of a solid by electromagnetic forces or chemical bonding. Activated carbon is the most common adsorbent which has been used for water and air treatment. It can be made from coal, nutshells or wood, which undergoes a process so that a highly porous structure is formed. Carbon adsorption can be used to remove a wide variety of contaminants from water and air. Common applications of carbon adsorption include groundwater treatment, chemical-spill response, industrial wastewater treatment, air-pollution control, and soil-venting and air-stripping off-gas treatment. Examples of organic contaminants which can be treated by carbon adsorption are: benzene, toluene, ethylbenzene, xylenes, trichlorolhene, tetrachloroethene, 1,1,1-trichloroethane, 1,2-dichloroethane, methyltert-butylether (MTBE), polynuclear aromatic hydrocarbons (PAH), pesticides, herbicides, and polychlorobiphenyls (PCB).

Most carbon-adsorption systems utilize granular activated carbon (GAC) with particle diameters of 1-4 mm in flow through fixed-bed column reactors. To design a GAC treatment system, the adsorption process in a fixed-bed column should be understood. When the bed is first brought on line, only the very top layer of the bed is exposed to the influent concentration since the adsorption depletes the contamination reaching the layers below. This depletion process establishes a finite depth in the bed, over which the concentration changes from the influent value [0 essentially zero. The column depth over which this occurs is called the "adsorption zone" or "mass transfer zone." As the top layer continues to adsorb, it eventually reached saturation, where the concentration in the carbon is in equilibrium with the influent, and the adsorption zone moves downward. The concentration of the effluent exiting the column will remain essentially zero until the adsorption zone reaches the bottom of the column. When the effluent reaches some pre-determined concentration, term the breakthrough, the adsorber is generally removed from service. A plot of effluent concentration versus elapsed time is a called breakthrough profile.

For a specific flow rate, there is a minimum depth of a carbon adsorber, which is required to accommodate the adsorption zone. If the bed depth is shorter than the adsorption zone, the carbon bed will immediately breakthrough and the effluent concentration will exceed the treatment Objective. As the bed is larger, the carbon will be utilized more efficiently. The main purpose of a GAC treatment system design therefore is to determine the optimum size and configuration of the adsorbers. In some cases, a multiple-adsorber operation, such as two beds in series, can reduce the carbon usage rate. With a single-bed operation, the carbon bed must be replaced when the effluent concentration reaches the treatment Objective even though the bed is not fully exhausted. With a bed-in-series operation, the first stage adsorber can still be maintained in line until it is saturated with the influent concentration. When the carbon in the first stage is fully utilized, it can be exchanged with fresh carbon and returned to service as the second-stage adsorber. After the bed is exhausted, the adsorbed contaminants can be removed from the spent by a process so-called regeneration or reactivation, which usually employs thermal incineration. For more information about Activated Carbon Vessels click here

Packed-Tower Air Stripping

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Air stripping is a process in which dissolved molecules are transferred from water into a flowing air stream. Air stripping is applicable for the removal of volatile organic compounds (VOCs) from contaminated water. Examples of common VOCS which can be treated by air stripping are benzene toluene, ethylbenzene, xylenes, trichloroethene, tetrachloroethene, 1,1,1-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, 1,1-dichloroethane, 1,2-dichloroethane, vinyl chloride, methylene chloride, and methyl-tert-butylether (MTBE). Air stripping has found its widest application in the remediation of groundwater contaminated from leaking underground storage tanks and past solvent disposal practices.

Air stripping is most widely accomplished in a packed tower with countercurrent flow of air and water. Contaminated water is pumped to the top of the tower and sprayed uniformly across the packing through a distributor. It flows downward by gravity in a film layer along the packing surfaces. Air is blown into the base of the tower and flows upward, contacting the water. The packing provides a very large surface area for mass transfer. Packings are normally made of polypropylene because of many benefits: inexpensive, chemically inert, lightweight and strong. VOCs are transferred from the water to the air and carried out the top of the column.

The design parameters for packed-tower air stripping are: 1) air-to-water ratio, 2) gas pressuredrop, and 3) type of packing media. Knowing flow rates of water to be treated, types and concentrations of contaminants, and treatment objectives, the design parameters can be selected to optimize the tower size and air-to-water ratio so that the lowest capital and operating costs will be obtained.

The VOCS emitted from the air stripping tower are diluted by the air stream and dispersed into the atmosphere. Many compounds, such as trichloroethene and tetrachloroethene will break down in the atmosphere under the effects of the solar radiation. However, due to the zero-discharge policy, several states in the U.S. have already require that all air discharges from stripping towers be treated before released to the atmosphere. The off-gases are usually treated by passing them through vapor phase carbon adsorbers. At first glance, this configuration appears superfluous since liquid-phase carbon could treat the water directly. However, this system may save on carbon usages and operating costs because vapor-phase carbon can often hold more contaminants before it becomes saturated. Organic chemicals can transport more easily through the air than the water. There are also fewer chemicals in the vapor stream competing for the available pore space since many harmless compounds will remain in the liquid phase. Other treatment techniques, such as thermal and catalytic incineration, may be more appropriate when the off-gas concentrations and carbon usage rates are very high. The operating cost for thermal and catalytic oxidation systems is dependent upon the amount of supplemental heat energy required to raise the process stream temperature to a critical point where near complete oxidation of the VOC contaminants occurs.

A common concern about stripping tower operation is plugging of the packing. Plugging may occur in some waters with very high iron and hardness contents. The dissolved iron can be oxidized to in the tower and precipitate out onto the packing. In an air stripping process, carbon dioxide can be stripped out of water, resulting in an increase of pH. If the water contains an appreciate hardness content, calcium and magnesium will precipitate in the forms of hydroxides. For iron and hardness contents less than 2 ppm and 200 ppm as Cac03' respectively, acids can be fed into the water stream to sequester the precipitation. For the higher iron and hardness contents, pretreatment of the water to remove iron and hardness is needed prior to the air stripping tower. Chemical oxidation using permanganate or preaeration with pH control, clarification and filtration can be used to remove iron. Lime softening can be used to remove the high content of hardness. For more information about air stripping click here

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Low-Profile Air Stripping

Low-profile air strippers can be classified into two major groups: multiple sieve-tray style and multiple diffused-chamber style. Carbonair's low-profile air strippers are in the former group in which water and air are contacted in step-wise fashion on multiple trays. Contaminated water enters at the top and flows downward by gravity. On the way, it flows across each tray and through a downspout to the tray below. The air passes upward through openings in the trays, then bubbles through the water to form a surface of foam which provides extreme turbulence and excellent mass transfer for organic volatilization. Since the water in sieve-tray air strippers flows horizontally across each tray, the traveling path length of water and the required removal efficiency can be achieved by increasing the number and length of the trays. Therefore the sieve-tray units have much lower height than the conventional packed-tower units.

When comparing the air utilization in sieve-tray air strippers to that in the diffused-chamber air strippers, only one air stream passes through every tray before exiting the sieve tray units whereas multiple air streams are introduced into the bottom of each chamber through diffusers such as perforated tubes or orifice. Therefore, the air requirement is much less than that for the diffusedchamber units. As a result of a minimal air flow, the organic contaminants in the off-gas are concentrated and can effectively be treated. The sieve-tray units also reduces the potential for fouling of suspended solids, iron and calcium since it contains no packing media and possesses an extreme turbulent condition.

Normally, the gas pressure drops encountered in sieve-tray units (10-30 inches W.C.) are higher than those in packed-tower air strippers (1-3 inches W.C.). This is due to the fact that the air must be bubbled through a thick layer of water in each tray. Therefore, the blowers for the sieve-tray air strippers usually are sized larger in horsepower. The Sieve-tray air strippers are recommenced for the application with the following requirements: height limitation, need for minimal visibility of equipment, high content of suspended solid, iron and hardness.