Water
Solutions

DuPont and ECT2 collaborate to remove 1,4-dioxane contamination from public groundwater and commercial water supplies using innovative synthetic media technology

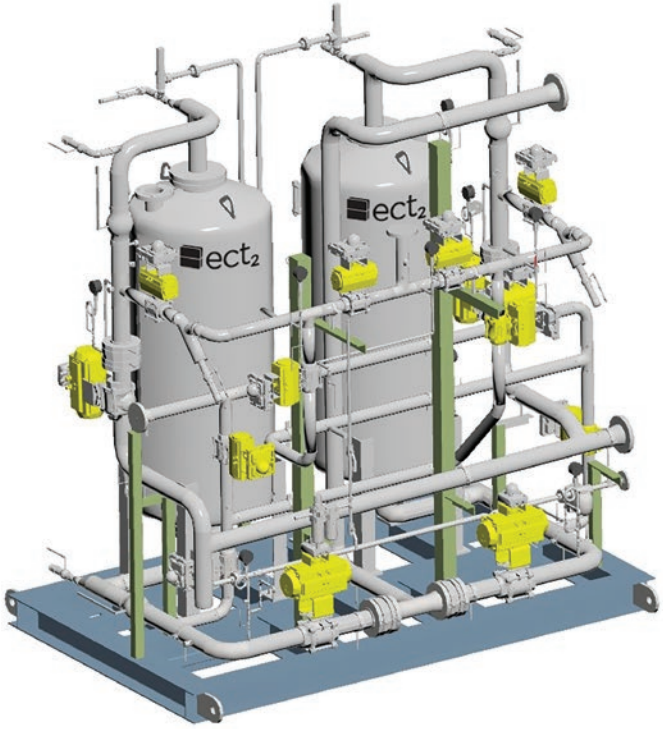
AmberSorb™ 560 Carbonaceous Adsorbent key to reducing 1,4-dioxane concentrations to 0.2 ppb

Beyond the regulated environmental contaminants monitored and controlled by the U.S. Environmental Protection Agency (EPA) is a class of compounds called "emerging contaminants." While these compounds – including 1,4-dioxane – are not yet regulated in water, the EPA and several states have established drinking water and groundwater safety guidelines.

1,4-dioxane has been detected at levels above established guidelines in groundwater and drinking water supplies, leading many local water utilities and various private organizations to move forward with remediation. Both DuPont Water Solutions (DWS) and Emerging Compounds Treatment Technologies, Inc. (ECT2) have pioneered solutions for the effective removal of 1,4-dioxane, an especially challenging contaminant.

Environmental and health challenges of 1,4-dioxane

Once widely used as a stabilizer for 1,1,1-trichloroethane – a chemical essentially phased out globally as part of the 1987 Montreal Protocol – today 1,4-dioxane is a by-product present in many goods, including paint strippers, dyes, greases, antifreeze, aircraft deicing fluids, and polyethylene terephthalate (PET) plastics. It is also used in the manufacture of consumer products, such as deodorants, shampoos and



Drinking Water

cosmetics, and as a purifying agent in pharmaceutical manufacturing.

In 2013, the EPA classified 1,4-dioxane as "likely to be carcinogenic to humans" by all routes of exposure. The U.S. Department of Health and Human Services (HHS) and the National Institute for Occupational Safety and Health (NIOSH) have also identified 1,4-dioxane as a potential carcinogen.

Highly miscible in water, 1,4-dioxane has leached into groundwater reservoirs in locations throughout the U.S. and it is resistant to naturally-occurring biodegradation processes. 1,4-dioxane travels rapidly to the subsurface, and once in groundwater, its plume can extend well beyond associated solvent plumes.

Difficult to detect, difficult to remove

The common practice, of analyzing potential contamination using a limited number of available methods, approved for regulatory compliance has often prevented detection of 1,4-dioxane in the past. Consequently, detection of 1,4-dioxane often must be specifically requested. And, while it is known that 1,4-dioxane is frequently a constituent of 1,1,1-TCA wastes, analytical methods could not enable its detection in the parts per billion range until 1997.

The properties that make 1,4-dioxane difficult to detect also make it difficult to treat. Because it is hydrophilic, conventional *ex situ* treatment technologies used for chlorinated solvents are not effective with 1,4-dioxane. Successful remedial technologies must take into account the challenging chemical and physical properties unique to 1,4-dioxane – which DuPont accomplished in 2012 with the introduction of AmberSorb™ 560 Carbonaceous Adsorbent.

AmberSorb™ 560 – a miscible organic contaminant treatment breakthrough

DuPont's AmberSorb™ line of carbonaceous polymeric adsorbents have been used for decades as a specialized sorbent in multiple applications. AmberSorb™ 560 Carbonaceous Adsorbent was designed as an alternative treatment technology for addressing the specific challenges of treating 1,4-dioxane and other miscible organic contaminants in groundwater and wastewater. It can also be used to remove various contaminants from vapor or atmospheric streams. The advanced adsorbent is regenerable *in situ* using low-pressure steam, microwave heating, hot gases or vacuum desorption.

ECT2 was formed to develop and deliver advanced technology products that efficiently mitigate the impact of emerging contaminants in both air and water. ECT2 not only worked closely with and supported DuPont during the development of AmberSorb™ 560 Carbonaceous Adsorbent, the company also developed an innovative treatment system for using it. Efficient and effective, ECT2's commercial synthetic media treatment system is able to effectively remove 1,4-dioxane contamination from groundwater.

The ECT2 system can consistently achieve compliance (e.g., less than 0.2 ppb in the system effluent) at varying influent conditions simply by adjusting the regeneration cycle frequency. The system does not require the use of dosing chemicals, ozone generators or the high-powered ultraviolet lamps typically associated with advanced oxidation processes. The simplicity of ECT2's system reduces operator oversight, increases compliance performance, is safer to operate and does not form unwanted by-products – such as bromate or hexavalent chromium – all at a low lifecycle cost. In addition, the use of AmberSorb™ 560 Carbonaceous Adsorbent provides effective adsorption throughout the pH range typically found in groundwater.

Groundwater remediation

The first customers of ECT2's full-scale remediation system were focused on removing legacy 1,4-dioxine contamination in groundwater. The challenge was treatment of 1,4-dioxane, other miscible compounds and volatile organic compounds (VOCs) from groundwater produced as part of long-term groundwater pump and treat remediation. ECT2 designed the system to treat up to 175 gallons per minute (gpm) of groundwater from wells located in and around residual contamination within the source area as well as the extended plume.

The groundwater was originally treated to control iron residuals prior to removing VOCs and 1,4-dioxane. During the system's early operation, ECT2 found that the iron removal step was not necessary for media protection, due to the inert properties of the AmberSorb™ 560 synthetic media and the zero headspace design of the treatment system. As a result, the Municipal Authority allowed dissolved iron levels to be discharged directly due to beneficial phosphorous reduction in the POTW. Other benefits of bypassing the iron pretreatment include increased filter run times, considerable reduction in iron sludge generation and reduced operation and maintenance costs. To date, there have been no adverse side effects associated with this approach.

There were several advantages for using AmberSorb™ synthetic media treatment versus other alternatives in this application:

- Many of the miscible compounds would not have been amenable to air stripping, and air stripper iron fouling would have been difficult to manage.
- The complexity and energy required for oxidation would have been prohibitive.
- Advanced oxidation processes had proven to be ineffective for achieving low-level discharge, given the complex groundwater geochemistry, elevated iron levels and stringent 1,4-dioxane discharge criteria.
- The hydrophobicity and engineered pore size distribution of AmberSorb™ 560 made it substantially more effective than granular activated carbon in this application.

The ECT2 system has operated with an uptime greater than 99 percent since startup in 2014. Influent 1,4-dioxane concentrations have ranged from 40 to 240 µg/L. Effluent concentrations since startup are reliably below discharge criteria for 1,4-dioxane and total VOCs alike, with a four-to-five order of magnitude removal efficiency. Operator training and process protocols have been standardized to focus on key performance indicators, assuring tight control and early recognition of undesired process variability.

Contaminated water supply solution for regional hospital

A regional hospital needed a quick and effective solution to not only mitigate 1,4-dioxane contamination in water used in mineral baths, but also to enhance their relationship with regulatory authorities and the community. Needless to say, patient populations require high levels of protection from unwanted compounds, such as emerging contaminants like 1,4-dioxane.

ECT2 designed a modular treatment package to address the hospital's need for a point-of-use, on-demand water treatment system. Based on a reduced-capacity, modular design of ECT2's M25 standard treatment system with a nominal capacity of 25 gpm, the hospital's system is compact, efficient, effective and well-suited for removing 1,4-dioxane and a broad range of other organic contaminants. And, ECT2 fabricated and delivered the skidded system in just 14 weeks – meeting the facility's requirement for rapid delivery and reliable long-duration operation.

Since installation, the system has consistently treated 1,4-dioxane to less than 0.2 µg/L detection limits or lower, meeting all current and proposed treatment standards using AmberSorb™ 560 Carbonaceous

Adsorbent. The modular system does not impact the mineral content of the water needed for mineral baths, and treatment results have been consistent, independent of changes in influent concentrations and flowrate. System simplicity enabled rapid installation and requires limited operator oversight. The regeneration of the AmberSorb™ 560 synthetic media is easily done onsite with no loss of adsorption capacity.

Proven solution for 1,4-dioxane removal

While the EPA has established a recommended drinking water concentration of 1,4-dioxane at 0.35 ppb, to date, there are no federally-promulgated standards at this time.

This could change soon. In 2018, the State of New York proposed a maximum contaminant level of one part per billion (ppb) for 1,4-dioxane. If passed, this would be the first enforceable U.S. drinking water regulation relating to this chemical.[1]

Meanwhile, 1,4-dioxane has been detected at levels ranging from 2.0 ppb to 11,000 ppb in many areas across the U.S.[2] More and more municipalities and private organizations are taking steps to remove this harmful chemical from their water supplies.

AmberSorb™ 560 Carbonaceous Adsorbent, coupled with ECT2's systems, is a proven technique to consistently remove 1,4-dioxane in groundwater and wastewater down to 0.2 ppb. Although relatively new, this synthetic media solution has demonstrated consistent performance over a wide range of concentrations and operating conditions. The system's ability to be regenerated in place using low-pressure steam, microwave heating, hot gases or vacuum desorption makes it a cost-effective and robust solution for many sites.

[1] Source: Environmental Council of the States

[2] Source: Chromatography Today

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