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## Using Biology to Treat Selenium

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*Biologically treating scrubber wastewater can be an attractive alternative to physical-chemical treatment.*

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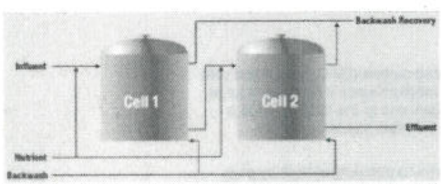
Increasingly stringent air quality regulations, starting with the 1970 Clean Air Act and including the more recent Clean Air Interstate Rule, are driving the continuous improvement of technologies that mitigate the effects of power generation pollutants. Pressures to continue improving emission controls will only increase as more coal-fired plants are built.

Decades of research and regulation have resulted in a steady evolution of best available environmental control technologies for new and retrofit applications. Flue gas desulfurization (FGD) is one way to protect air, water and soil from sulfur dioxides and heavy metal contaminants produced by coal combustion. However, once commercially viable by-products such as gypsum are removed from the FGD lime slurry, the process water can contain dangerous concentrations of toxic metals including selenium, mercury, arsenic, lead, copper and chromium. These must be reduced to levels established under the National Pollutant Discharge Elimination System (NPDES) before the water can be released into the environment.

Selenium is an essential nutrient at low levels; however, it can become toxic at concentrations only twice the beneficial levels. This can result in many short- and long-term health effects including damage to the nervous system and a decline in reproduction. As selenium moves from water and into wildlife, it can bioaccumulate in organisms and become more concentrated in species that are higher up on the food chain, eventually reaching highly toxic levels.




*An ABMet system incorporates a series of bioreactors that contain a bed of granular activated carbon (GAC) and site-specific bacteria to handle the waste stream.*

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Much of the coal mined and used in the eastern United States is high in selenium. This requires many power producers to include selenium removal as part of their FGD wastewater treatment systems to protect the environment. Recommended water quality criteria for selenium can be below 0.020 parts per million (ppm), and the Environmental Protection Agency (EPA) currently regulates the maximum contaminant level (MCL) of selenium in drinking water at 0.05 ppm. As a result, the amount of selenium that must be removed from the waste stream will vary from plant to plant, based on the type of coal being burned and on discharge limits set by local regulatory agencies.

Physical-chemical processes can be used to remove some heavy metals from the FGD waste stream and other industrial wastewaters. The disadvantages of chemical processes include the high cost of reagents and difficulties reducing the selenium level to a concentration that complies with NPDES requirements. Furthermore, these treatments are not effective in removing the most common forms of aqueous selenium. They also require large quantities of chemicals and generate significant amounts of sludge that must be properly disposed of. For example, iron can be used as a reductant to precipiate some forms of selenium from the wastewater, but this process can produce many times more sludge than a microbiological process.

Constructed wetlands can also be considered for biological selenium removal and are relatively inexpensive to operate. However, building wetland systems typically requires several acres of land and leaves contaminated water accessible to wildlife. And this approach does not necessarily provide certainty about the consistency of pollutant removal. Although constructed wetlands provide a means to remove pollutants from the wastewater, they are not designed to provide an effective process for removing pollutants from the system. Toxins accumulate in the sediments, plants and aquatic organisms of constructed wetlands, posing a risk to wildlife.

An engineered microbiological approach provides a more effective way for the power industry to remove dissolved metals, nitrate and other inorganic contaminants from the FGD wastewater stream. An advanced biological wastewater treatment process that uses naturally occurring, non-pathogenic microbes to reduce and precipitate target compounds such as selenium offers a potentially effective and environmentally sound method of removing dissolved metals, nitrate and other inorganic contaminants.

### A Biological Approach

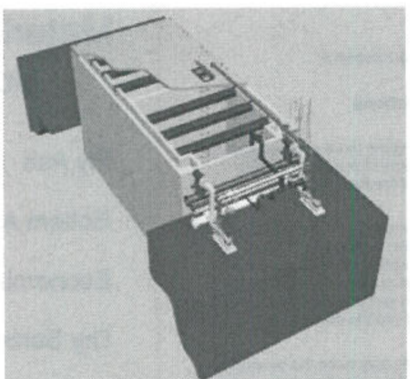
GE Water & Process Technologies' ABMet biological treatment is capable of exceeding current treatment requirements, reducing selenium concentrations by more than 99 percent, often to less than 0.010 ppm. Significant levels of other toxic metals can also be removed from the FGD wastewater- typical removal results for other pollutants includes less than 150 ppt mercury, less than 10 ppb arsenic and less than 10 ppm total nitrogen.

Four ABMet projects to treat FGD wastewater are currently in design or under construction in the United States, with the first scheduled to start in 2007. Treatment capacities for these southeastern U.S. plants range from about 190,000 gallons per day (GPD) to 2 million gallons per day (MGD); the scalability of the ABMet system means it can be sized to treat FGD wastewater from coal-fired power plants of any size.

ABMet biological wastewater treatment process is less complex than conventional wastewater treatment systems and offers process controls that produce possible advantages including minimal sludge generation, virtually no chemical addition, minimal power requirement, a compact plant footprint and scalability to meet site demands.

Several factors are considered when configuring an ABMet system. Once the target metal and inorganic compounds are identified in the FGD wastewater stream, the bioreactors can be inoculated with selected bacteria cultures that can remove contaminants from the water. Retention time in the bioreactor is typically only a few hours, but will vary depending on the temperature, water chemistry, suspended solids and required effluent standards.

The process is capable of operating at temperatures as high as 105 F and able to adapt to changes in wastewater composition caused by burning coal from various sources. Prior to treatment, the power plant's FGD system sprays lime or limestone into a scrubber tower. The alkaline sorbent reacts with the sulfur dioxide gas and is collected in a liquid form as calcium sulfite or calcium sulfate slurry. Following forced-air oxidation, the slurry flows to a treatment system where the calcium is removed by settling or other means. Once dewatered, the calcium sulfate, or gypsum, can be manufactured into wallboard. The resulting wastewater, following a clarification step, can be directed to the system for treatment before it is discharged into a receiving body.



*Wastewater flows through the bioreactor, contacting microbial mixtures at a specific rate and retention time, ensuring that a reducing environment is maintained. Precipitated contaminants remain in the biomatrix until flushed out for recovery or disposal.*
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The process incorporates a series of bioreactors, each containing a bed of granular activated carbon (GAC) inoculated with site-specific bacteria to handle the waste stream. GAC offers the bacteria an ideal growth medium since it has a very large, irregular surface area that helps to shelter the biomass in the reactor. "Fixing" the microorganisms to the GAC creates a biological film that retains the biomass and the precipitated contaminants in the system to maintain stable operation.

Influent wastewater is introduced to the bioreactor and moves through the activated carbon and microorganisms by plug flow, ensuring a constant wastewater velocity and eliminating any mixing within the bioreactor. Plug flow also helps operators precisely control the biological processes since it is relatively simple to determine the residence time of the wastewater in the bioreactor.

Retaining the microorganisms on the GAC is a key design feature in establishing a decreasing redox potential gradient in the carbon beds. This creates multiple zones within the bioreactor that are each capable of reducing different contaminants. This environment is much different than conventional bioreactors that are completely mixed and can only operate at a single redox level.

Precise control over the redox level optimizes the removal of target contaminants. Changes to the nutrient levels can therefore be used to target contaminants such as nitrate and selenium. This is the primary reason why selenium removal is so effective

Fundamental biochemical reactions occur in different zones of the activated carbon matrix. At the entrance of the bioreactor, nitrate is reduced to nitrogen gas, which is released to the atmosphere. Selenium is reduced from an oxidized state to an elemental state and forms nanospheres that attach to the cell walls of the reducing microbes. Since these microbes are attached to the activated carbon, the selenium is essentially bound to the growth media to await removal.

In addition to selenium reduction and denitrification, the system will also remove other metals. Sulfide produced in the system readily forms metal complexes with zinc, copper, nickel, lead and other primary metals that precipitate out of the effluent and remain in the bioreactor. Denitrification is also carried out as the sulfate and selenium are reduced.

Treated wastewater is fed into a second bioreactor. A site may have several bioreactor trains that operate in series to achieve the optimum level of metals removal. Wastewater flows vary from site to site, and can exceed 1,500 gpm at large power facilities. The process is scalable and can accommodate large or increasing flows by building additional.

The carbon beds in the bioreactors must be flushed periodically to remove total suspended solids, biomass and inorganic contaminants that have been converted to solid forms. The automated flushing process fluidizes the bioreactor dislodging rapped particles and accumulated solids, while retaining the activated carbon.

Regardless of a power plant's current situation, regulatory agencies continue to review and revise rules for toxin emissions to protect drinking water supplies and preserve the environment. Effective, affordable, reliable and environmentally responsible treatment systems provide the most effective and lowest cost solutions for power producers to achieve today's standards and prepare for increasingly stringent regulations in the future.

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