# Selenium Removal Options

## Selenium — Good and Bad

Selenium is a photosensitive element that occurs in both crystalline and amorphous forms, is obtained chiefly as a byproduct in copper refining, and is used especially in glass, semiconductor devices, and alloys. Although selenium is an essential micronutrient for animals and humans—its prime benefit is as an antioxidant—it is the most toxic of the essential elements when it is in excess. The margin between healthy and toxic levels is very narrow and it bioaccumulates, so aquatic life up the food chain is most at risk. In fact, there have been occurrences of severe embryo deformities observed in aquatic life where selenium is elevated.

## Selenium … in the Air

Additional uncertainty regarding selenium issues is related to changes in air quality rules by the EPA. Selenium is frequently present in low concentrations in coal used by power plants to generate electricity. In 2005, the EPA implemented the Clean Air Interstate Rule, the Clean Air Mercury Rule, and the Clean Air Visibility Rule. These rules are intended to dramatically reduce sulfur dioxide emissions along with haze in national parks and wilderness areas. As a result, it is expected that many new, more effective flue gas desulfurization (FGD) scrubbers will be installed by coal-fired power plants. These FGD scrubbers are expected to produce wastewaters containing trace levels of selenium and require treatment prior to discharge.

## Selenium Treatment … Is it Working?

Selenium is generally present as selenite (HSeO3- or SeO3-2), selenate (SeO4-2), organic complexes, and, under strongly reducing conditions, selenide (HSe-). It is very difficult to remove from solution, very soluble, and there are no known precipitants. An incorrect assumption frequently made is that it will behave like arsenic. Most common removal technologies are interfered with by other competing anions present (silicate, bicarbonate, sulfate). The list below shows the difficulties in standard treatments:

- Ferrihydrite adsorption. The EPA's Best Demonstrated Available Technology for selenium removal is ferrihydrite adsorption. However, this approach is only effective for selenite, not the other potential selenium forms, and even for selenite it requires fairly specific conditions, and is significantly interfered with by other anions present in solution.

- Membranes. Membrane processes such as nanofiltration and reverse osmosis, are not selective for selenium species, are energy-intensive, and are subject to scaling.

- Ion exchange. Ion exchange is generally not selective enough for selenium species in the presence of competing anions.

- Selective resins. Selenium-selective resins are being developed, but they are expensive and considered experimental. Their high selectivity can make them very difficult to strip and regenerate.

- Activated alumina adsorption. Adsorption with activated alumina can be fairly effective under proper pH conditions, but suffers from interference from competing anions, and performance is poor for selenate.

- Activated carbon adsorption. Adsorption by activated carbon is ineffective for selenium removal.

- Ferrous hydroxide reduction. The U.S. Bureau of Reclamation developed a process using ferrous hydroxide as a reductant under specific process conditions to reduce selenite and selenate to elemental selenium. While effective, this process has a high reagent requirement and produces significant sludge volumes.

- Biological reduction. Using bacteria to reduce selenite and selenate to elemental selenium or selenide has been performed effectively; however, biological systems are always vulnerable to upsets in process feed conditions, nutrient delivery, temperature, etc.

Solution: Electrocoagulation

The removal of selenium may need more residence time for the desired removal target. EC will remove approximately 44% during the normal one minute residence time in the EC chamber. Each pass or each additional minute in the electron-flooded water will result in a subsequent 44% removal of selenium.

Electrocoagulation (EC) will significantly reduce BOD, TSS, TKN, phosphate, silica, heavy metals, and other contaminants from aqueous solutions. With the use of electricity, electrocoagulation efficiently removes a wide range of contaminants with a single system. The EC makes constituents in the water “separable”. Heavy metals are converted from ion forms to oxide forms, allowing them to be disposed in a non-hazardous landfill. Because electrocoagulation utilizes methods that precipitate out large quantities of contaminants in one operation, the technology is the distinct economic and environmental choice for industrial, commercial and municipal waste treatment. The capital and operating costs are usually significantly less than chemical coagulation.

15 gpm Electrocoagulation Unit