Removing Thallium from Industrial FGD Scrubber Water with Sorbster® Adsorbent Media

Trace thallium levels in process and wastewater streams pose a human toxicity threat. Tidwell et al. (European Journal of Mineral Processing and Environmental Protection, Vol. 2, No. 1, 2002) report that thallium is more toxic to humans than mercury, cadmium, lead copper or zinc. Thallium occurs almost exclusively in natural waters as monovalent thallium Tl^{+1} cation. The water solubility of thallium compounds is relatively high so that thallium is readily transported through aqueous routes into the environment. The primary source of thallium is sulfide minerals and it is found in mineralized areas interspersed with sulfide deposits. As a result, it occurs as a trace contaminant in mining water runoff and in flue gas desulfurization scrubber waters from coal combustion where the coal contained associated sulfide deposits.

In 2014, as part of a study of heavy metals removal from coal-fired power plant flue gas desulfurization scrubber water systems, Sorbster® adsorbent media was tested extensively. The media demonstrated a high proficiency for the primary contaminants targeted in the study, namely mercury, selenium and arsenic, but it also simultaneously removed thallium. This case history summary discusses the outstanding removal of thallium throughout the treatment of 3000 bed volumes of scrubber water and the ease of use of this adsorbent technology.

The treatment was performed at a large three-unit coal-fired power plant with a total nameplate rating of 2,933 MW located in the eastern USA. This plant has historically operated utilizing a blend of low-sulfur and Northern Appalachian high-sulfur coals. Flue gas scrubber water from all three of the Units composed the effluent wastewater stream. The removal of thallium and other contaminants from the effluent wastewater stream is necessary to meet discharge permits, recycle the water and protect the environment.

The Sorbster Removal System

A slipstream of this plant effluent wastewater was treated continuously on-site through a system of Sorbster® media vessels. The media was loaded into the vessels and backwashed with plant water to wet and rinse fines from its surface before being put into service.

Image - The Sorbster® Media Treatment Unit consisting of four vessels plumbed for series water flow. This unit is equipped with inlet and outlet pH measurement, inlet water conductivity, a pump, flow controllers, flow totalizers and pressure drop

Each of four vessels on the treatment skid contained a bottom layer of gravel to support the media and 45 lbs. of media. Total Sorbster® MM-1 media in all four vessels was 180 lbs. Sorbster® MM-1 media is a 1/8" solid spherical material consisting of an activated alumina substrate that has been functionalized with specific active sites suitable for the rapid covalent bonding of both cationic and anionic soluble contaminants from industrial process and wastewater streams. When Sorbster® media is manufactured, the functionalization of activated alumina takes place at high temperature in a reaction with specific added chemistries. The media is traditionally used for the removal of mercury, arsenic and selenium but has shown a high proficiency for the removal of thallium from many industrial waters.

In this application, the FGD scrubber wastewater was pumped through the vessels at 0.4 gpm. There was a 5-micron filter on the inlet line to the Sorbster® media treatment skid. No other pretreatment of the water was done. Specific treatment parameters were as follows:

- Water-to-Media Contact Time (based on empty bed volume): 60 minutes
- Thallium Sampling: approximately every 8 days of the inlet and treated effluent waters
- Thallium Measurement: ICP Method E200.7 with detection limit of 0.032 µg/L
- Inlet water pH: 7.0
- Bed Volume of the Sorbster® media Unit (based on empty bed volume): 28 gallons
- Typical Bed Volumes Treated per Day: 24 BV
- Number of days of treatment: 126 days
- Total Bed Volumes Treated: 3000 BV
- Series flow of the water through vessel #1 into #2, then into #3, then into #4
- Treated effluent samples were taken as water exited vessel #4.

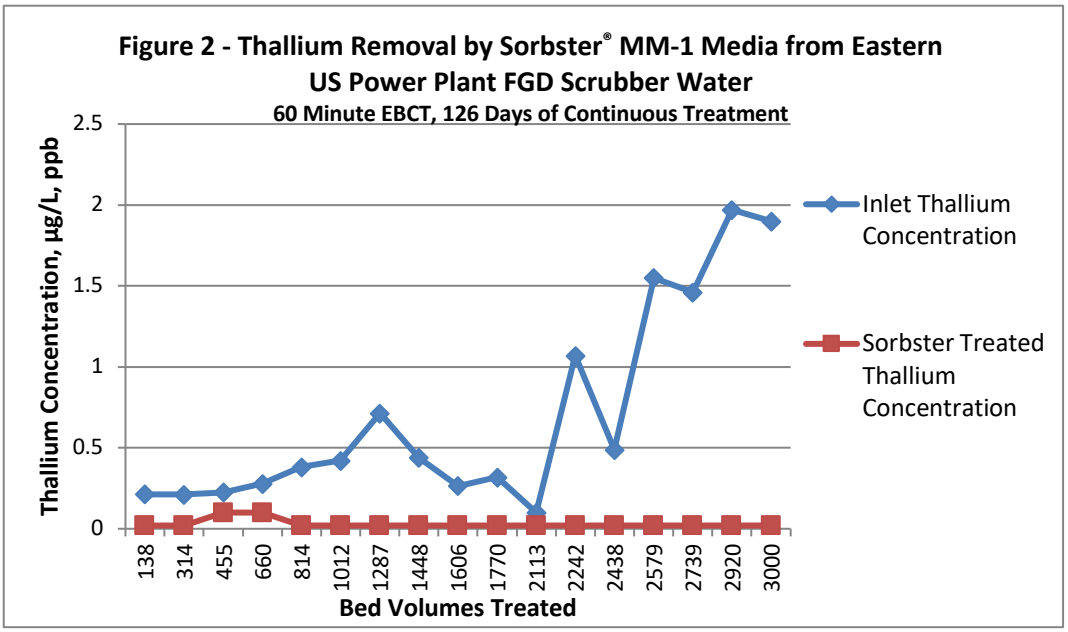
The Inlet Water Quality

Like many flue gas desulfurization systems, this forced oxidation scrubber utilized limestone for SO_2 removal resulting in a wastewater that contained high levels of calcium, magnesium, chloride and sulfate along with trace levels of numerous metal contaminants. Thallium was present during the 126 day treatment application across a range of concentrations from as high as 2 µg/L down to a low of 0.1 µg/L. The highest concentrations occurred in the latter portion of the trial. Both total and dissolved thallium were measured on the inlet water and the numbers typically matched, indicating that the thallium was present in a dissolved state.

Average Inlet Water Quality to the Sorbster® Media Vessels	
Calcium	1300 mg/L
Magnesium	2000 mg/L
Sulfate	4300 mg/L
Chloride	4200 mg/L
Nitrate	10 mg/L
Thallium	0.66 µg/L (0.1 low to 2.05 high), all thallium was in a soluble form

The Results

Strong and sustained removal of thallium was achieved by Sorbster® adsorbent media (Figure 2). The thallium level in the treated effluent from the Sorbster® media vessels was never found to exceed the 0.032 µg/L detection level of the thallium analytical method. Thallium removal was continuously > 90%. The high ionic strength of the water and its variability were handled by the media and did not affect thallium removal.



At 3000 bed volumes treated, the media showed no sign of exhaustion or capacity loss. Removal was continuous to a level of < 0.03 µg/L. This occurred even in the presence of a significant and continuous climb in the inlet water thallium levels beginning around 2113 bed volumes treated. When the application concluded at 3000 bed volumes treated, 0.007 lbs. of thallium had been removed from the 85,000 gallons of water treated and the media was expected to continue removing thallium at the same high removal rate.

Following the application, used media was tested for metals release. The media released no metals and passed the EPA's TCLP testing for disposal in a non-hazardous landfill.

Conclusions and Benefits

- Sorbster® MM-1 Adsorbent Media is an excellent choice for treating for thallium in industrial waters
- The media can be deployed in standard flow-through vessels
- Removal rate for the thallium cation is high (>90%) and sustained
- The media is capable of achieving thallium removal to < 0.03 ppb levels
- Water-to-media contact time is the control parameter
- Thallium removal can be achieved by Sorbster® media without additional pretreatment steps and the media functions well in high ionic strength waters
- The estimated media life for thallium removal is 8 to 12 months depending upon water quality
- Thallium removal performance is applicable to FGD, mining and all industrial water systems
- Sorbster® media is an easy to use "plug and play" treatment option requiring only water flow
- In addition to standard tanks, Sorbster® media can be utilized in any temporary tank capable of water flow. Recommended flow flux/hydraulic loading is 1 to 6 gpm/ft²
- Spent Sorbster® media passes the EPA TCLP leach test for non-hazardous disposal options
- Contact Sorbster for further information