USE OF CHLORINE DIOXIDE FOR BIOFILM CONTROL IN A PACKED-BED, VOC SCRUBBER SYSTEM

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INTRODUCTION

Excessive biofilm growth is a potential issue for packed-bed wet scrubber systems that use water to absorb volatile organic compounds (VOCs) from influent gas streams. Water soluble compounds such as methanol, ethanol, isopropanol, butanol, acetone, and formaldehyde are effectively removed by this technique, with typical removal efficiencies in excess of 90 percent. However, this continuous carbon source can create and sustain significant biofilm communities that coat the wetted surfaces of the media and, if left unchecked, will eventually "plug" the system and decrease its removal efficiency. In addition, as the plugging progresses, it is typically necessary to increase the fan speed of the system to maintain the optimum vacuum at the scrubber inlet, which increases power requirements and decreases detention time through the media.

Chlorine dioxide is one chemical that is receiving increasing attention as a general biocide and for biofilm control in a variety of water treatment applications, in both the municipal and industrial sectors. The scrubber systems that were the focus of this study had used bromine-based compounds for several years, with generally mediocre results, prior to conducting the chlorine dioxide trial. The limited effectiveness of the bromine compounds necessitated the use of a second biofilm control process: the application of a 35 percent hydrogen peroxide solution on a monthly basis. The objective of this study was to demonstrate the effectiveness of using chlorine dioxide alone for biofilm clean-up and control in industrial packed-bed wet scrubbers designed for VOC removal. Color photographs of the media were taken to document the results.

MATERIALS AND METHODS

Wet Scrubber Systems. This trial was conducted on two similar wet scrubber units at an industrial site in the western United States over a 3-month period in late 2010. The scrubbers remove VOCs from the influent process air and operate in a cross-current mode (Figures 1 and 2). The capacity of each scrubber is 70,000 cfm. During the trial they operated at 33,000 and 18,000 cfm. The total system water volume is 1200 gallons with a recirculation rate of approximately 550 gpm.

Chlorine Dioxide Solution and Dosing. The only biocide used during the trial was a 0.3 percent aqueous chlorine dioxide solution (ACD-300, International Chemtex). This stabilized, ready-to-use chlorine dioxide solution has a shelf-life of 9 months and was fed from 55-g drums using standard chemical metering pumps (Figure 3). Although the polyethylene tubing shown in Figure 3 is acceptable in the short-term, Teflon® or Kynar® tubing is recommended for long-term applications. The bromine-based biocides that had been used for approximately 7 years were discontinued just prior to the start of the trial, at which time a significant mass of biofilm was present (Figures 4 and 6).

For the initial 3-month trial, which was considered a "clean up" period for the scrubber, 2.5 gallons of chlorine dioxide solution were added 3 times per week. The solution was added in a semi-slug mode, i.e. at a high rate so that the dosing was complete within 15 – 20 minutes. The overall chlorine dioxide dose to the system was 6.25 mg/L. For chlorine dioxide, this dose is relatively high for biofilm control applications. However, given the magnitude of the biofilm mass, a higher dose was deemed necessary, with an assumption that the dose would be optimized after biofilm control was attained.

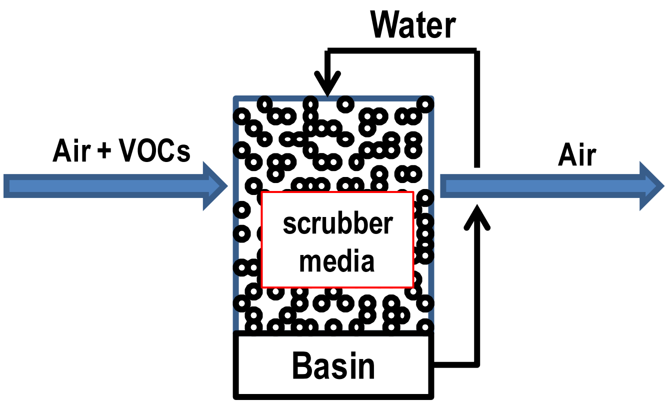

Figure No. 1.
Flow schematic of VOC wet scrubber system. Total water volume was 1200 gallons with a recirculation rate of approximately 550 gpm.

Figure No. 2.
Wet scrubber #1 48"-diameter air inlet. Air flow was approximately 33,300 cfm during trial (design flow = 70,000 cfm). Maintaining an optimum vacuum at this inlet is crucial to operation of the unit.

Figure No. 3.
Aqueous chlorine dioxide solution being fed from 55-g container during the trial. Drum fitting (Colder) is high-density polyethylene (HDPE) and tubing from drum to pump is polyethylene. Teflon® or Kynar® tubing recommended for long-term applications.

Selection of Biofilm Monitoring Sites. Photos were taken prior to chlorine dioxide application to record the initial presence of biofilm in the plastic media and again three months later, at the conclusion of the trial. A fiberglass window, which allowed clear views into the scrubber media, was provided on each side of the units. Photos were taken from these locations.

Water Quality. The scrubber feed water is treated municipal potable water from the City of Colorado Springs. Limited water quality data for the feed as well as the scrubber process water are provided in Table 1.

Table 1. Scrubber feed and process water quality (average values).

Constituent	Makeup Water	Scrubber Process Water
Conductivity (microsiemens)	100 – 200	1900
Total organic carbon (mg/L)	1.0 – 2.0	na
Total alkalinity (mg/L as $CaCO_3$)	30 - 40	na
pH (std. units)	7.8	7.3

RESULTS AND DISCUSSION

Biofilm Destruction and Control. Figures 4 – 7 document the impact of chlorine dioxide on the biofilm in the two scrubber units. As shown in Figure 4 (scrubber #1), although bromine-based compounds had been applied regularly prior to the trial, a significant mass of biofilm was present. This magnitude of biofilm growth adversely affected the scrubber operation by requiring steadily increasing fan speeds (i.e. increased energy costs) to maintain a vacuum at the scrubber inlet. At the time the trial was commenced, the vacuum at the inlet had fallen from approximately 2.1 inches of water (optimum) to 0.3 inches of water. Additionally, a monthly cleaning of the media with a 35 percent hydrogen peroxide solution was needed, which required a system shutdown. As shown in Figure 5, which was taken after the 3-month “clean-up” period, chlorine dioxide was

Figures No. 4 and 5.
Figure 4 (left) shows significant mass of biofilm (light brown areas) in scrubber #1 media prior to the application of chlorine dioxide. Figure 5 illustrates the clear impact of chlorine dioxide after 3 months of application.

Figures No. 6 and 7.
Figure 6 (left) shows significant mass of biofilm (light brown areas) in scrubber #2 media prior to the application of chlorine dioxide. Figure 7 illustrates the impact of chlorine dioxide after 3 months of application.

extremely effective in completely destroying the biofilm and preventing any significant re-growth. Similar results are shown in Figures 6 and 7.

Cost Savings. Although exact data were not available, the destruction and removal of the biofilm by chlorine dioxide solution decreased power costs by allowing the scrubber fans to be operated at significantly slower speeds while still maintaining optimum vacuum at the scrubber inlet. In addition, labor requirements were decreased because the monthly shutdowns/cleanings with 35 percent hydrogen peroxide were obviated.

CONCLUSION

A 0.3 percent aqueous solution of chlorine dioxide proved to be very effective for eliminating and preventing re-growth of biofilm in an industrial wet scrubber system used for VOC removal. Chlorine dioxide proved to be far more effective than the bromine-based compounds that had been used for years with generally mediocre results. The success of the chlorine dioxide trial has led to its continued use at the industrial site and the installation of a permanent feed system.