Metals Removal Using Aqua-Aerobic Systems Technologies

Introduction

Regulations on heavy metals levels in effluent streams from wastewater treatment facilities is becoming increasingly prominent. To meet these regulations, current facility owners and operators are looking for reliable, effective solutions that will guarantee permit levels are met. Aqua-Aerobic Systems provides a variety of technologies that can help facilities meet these permit limits. The purpose of this document is to demonstrate how these treatment technologies can be used for metals removal.

Metals Removal

Without modification, wastewater treatment plants remove a significant fraction of certain metals through solid-liquid separation and biological accumulation. For example, treatment plants have been shown to remove about 50% of zinc, 60% of copper, 79% of lead, and 1% of nickel (E. Kulbat *et al.*, 2003). This amount of removal combined with generally low influent concentrations allows many municipal facilities to meet their effluent requirements for metals without modification.

In cases where the existing treatment plant is unable to meet the effluent metals requirements, improvements can be made to increase the removal. When evaluating improving metals removal, it is worthwhile to determine if the current metals are in a soluble or particulate state. If the metal of interest is mostly particulate, reducing effluent solids through filtration will likely reduce the effluent metal concentration. If the metal is in soluble form, additional precipitation steps are needed before removal. The precipitation steps required will depend on the metal. In some cases, metals can be precipitated using alum or ferric. In other cases, the metal needs to be precipitated by adjusting the pH. Metals solubility significantly decreases as pH increases. As such, at 6.0 pH the solubility copper is 20 mg/l and at pH of 8.0 the solubility is 0.05 mg/l (Hoffalnd, 2017)

Aqua-Aerobic Systems biological systems and filtration technologies are well suited for metals removal. The biological mechanisms for uptake of metals are common among treatment technologies. What differentiates Aqua-Aerobic Systems technologies in metals removal is the ability to minimize the effluent TSS. The AquaSBR® sequencing batch reactor minimizes effluent TSS by having an adjustable settle phase and using a floating decanter that excludes surface scum. Aqua-Aerobic cloth media filters are designed to maximize solids removal using any one of the five options for OptiFiber® cloth filtration media. In addition, cloth media filters are able to remove particulate generated through precipitation.

Studies

Since 2015, Aqua-Aerobic Systems has been conducting metal removal studies in some plants, as the opportunity arises. As part of these efforts, testing was done in SBR systems followed by Cloth Media Filters. In 2018, a more formal study was conducted which included survey of 133 treatment plants throughout the United States to identify the most common heavy metals permit requirements.

The results from this survey are presented in Figure 1. The five most common metals are copper (Cu), zinc (Zn), mercury (Hg), cadmium (Cd), and lead (Pb).

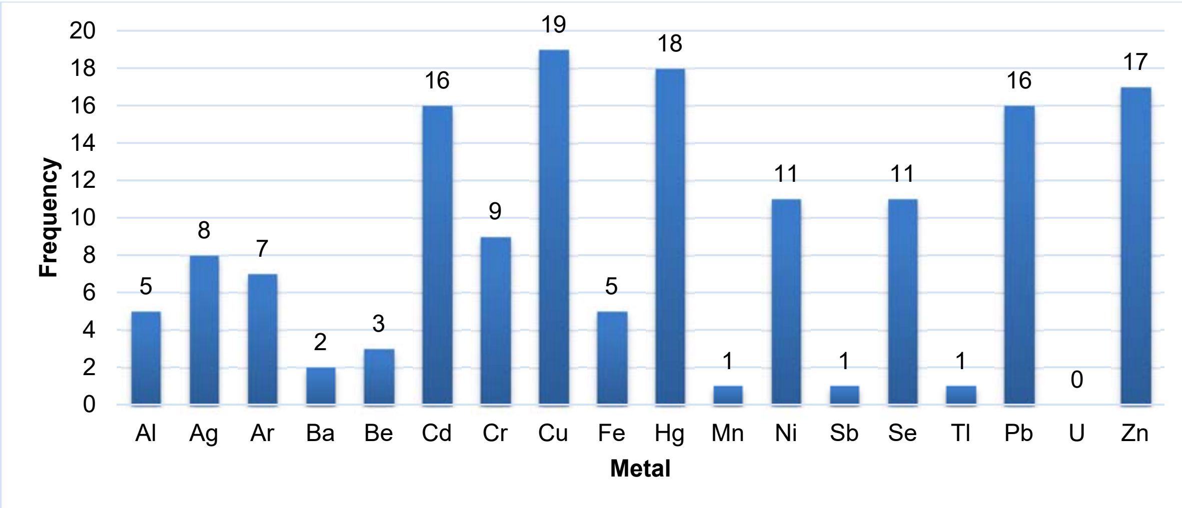

Figure 1: Frequency of effluent requirements for heavy metals from 133 facilities

Data Collection and Testing

Data collection included existing full-scale plants and pilot units. The data included interpretation of existing data from the plant's DMR, as well as, specific sampling of the influent and effluent conducted by Aqua-Aerobic Systems.

The testing focused mainly on copper, lead, and zinc. Due to limitations on the methods of detection some metals were not tested at every location. All samples were collected at functioning wastewater treatment facilities under operating conditions. Testing was completed at a total of four AquaSBR® sequencing batch reactor facility and seven locations with AquaDisk® cloth media filters.

The most recent data collection was performed during the months of June, July and August of 2018. No modification was made to the normal operation at the full-scale facilities. In addition, testing of metal removal was performed at Aqua-Aerobic's Research & Technology Center located at the Rock River Water Reclamation District (RRWRD) in Rockford, IL. The purpose of this testing was to study the capability metal removal via filtration with the addition of coagulant and polymer.

Removal of Copper

Copper removal was measured at four SBR facilities and five samples were taken. The results from the SBR facilities are shown in Figure 2. Most plant had over 90% removal with the highest at 95% reduction in copper across the SBR, which greatly exceeded the expected removal from literature of 60%.

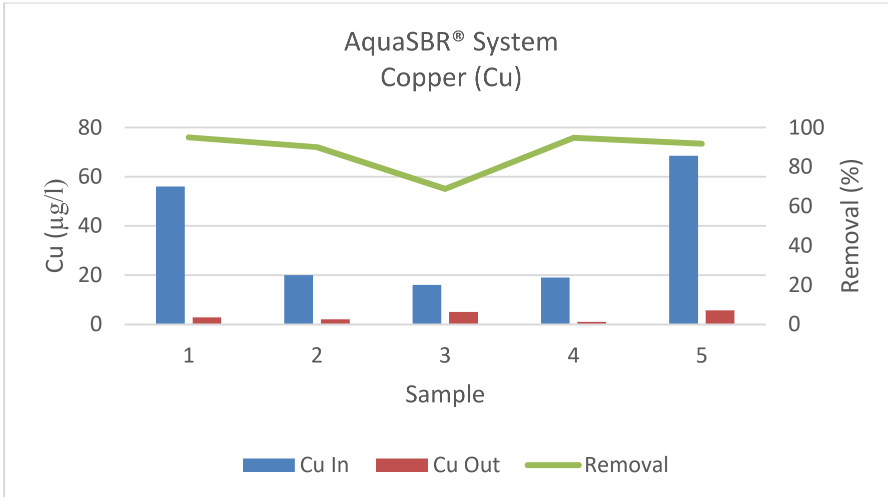

Figure 2: Copper reduction at AquaSBR installations

Samples were taken at 7 total locations between all the studies. Figure 3 shows several filter influent and filter effluent samples from an AquaDisk cloth media filter with OptiFiber PES-14® cloth filtration media. Filter influent copper concentrations were very low, which makes additional removal difficult. However, the filter removed between 8.5 and 50% of the influent copper.

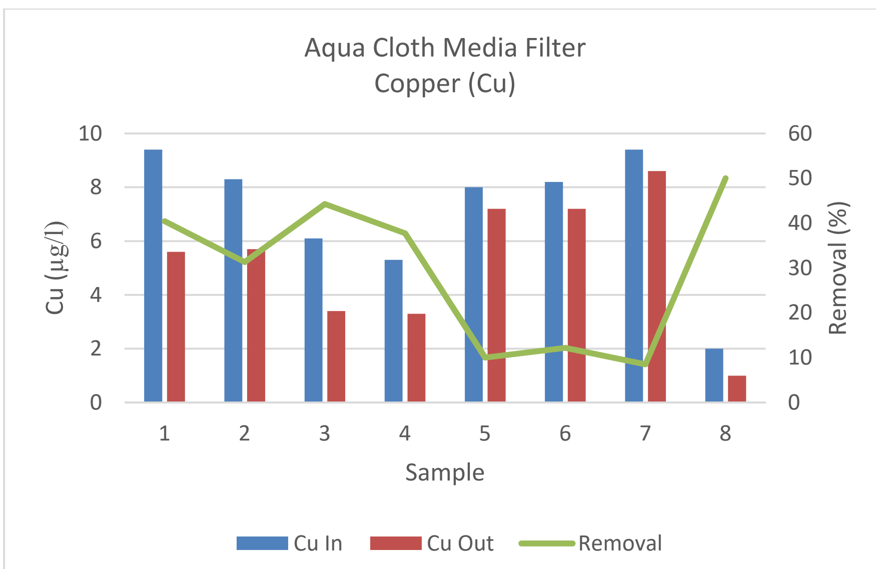

Figure 3: Copper Removal at Cloth Media Filter Installation

Copper removal testing was also completed on a low total phosphorus pilot study. Ferric chloride and polymer were used to minimize the effluent total phosphorus. Figure 4 shows the results from these samples. The influent sample was collected prior to the addition of ferric chloride. It was later discovered that the ferric chloride used contained 120 mg/L of copper, which explains the increase and serves as a caution when using ferric chloride at sites with effluent copper objectives.

6306 N. Alpine Rd. Loves Park, IL 61111-7655 p 815.654.2501 f 815.654.2508 www.aqua-aerobic.com

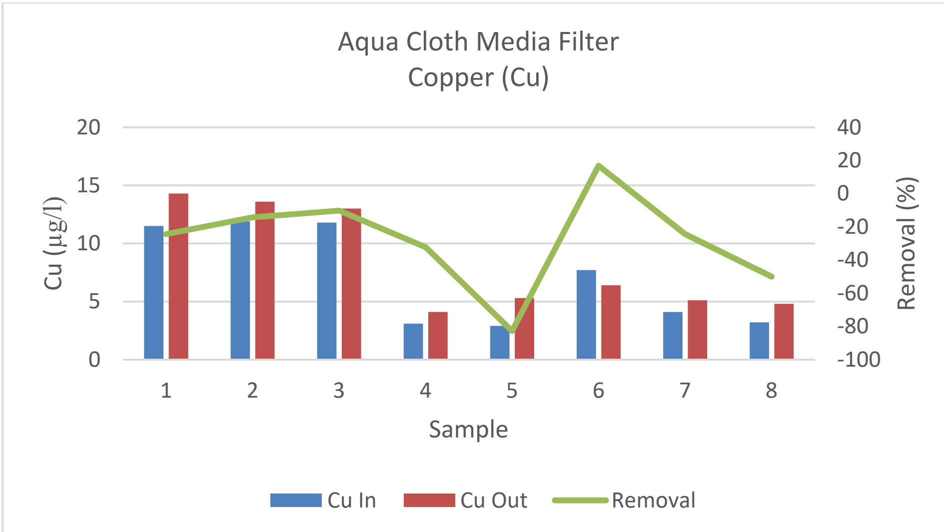

Figure 4: Filter influent and effluent polymer on pilot study with ferric chloride and polymer

Removal of Lead

Lead removal was monitored on one SBR site and across the cloth media filter at two sites. The concentration of Lead in all the sites tested was very low, which made it difficult to show a significant reduction. Lead levels on those sites were relatively close to the analysis detection limit. Efforts were made to show if adding polymer to one of the filtration sites would show lead removal. While some removal was experienced, the influent levels were so low that it was not possible to determine how much removal. Further tests would be required on sites with higher influent Lead concentration.

Removal of Zinc

Zinc reduction was tested in the influent and effluent of two SBR sites. Figure 5 shows the consistent reduction at both sites of approximately 65% removal of Zinc compared to the text book value of 50% removal.

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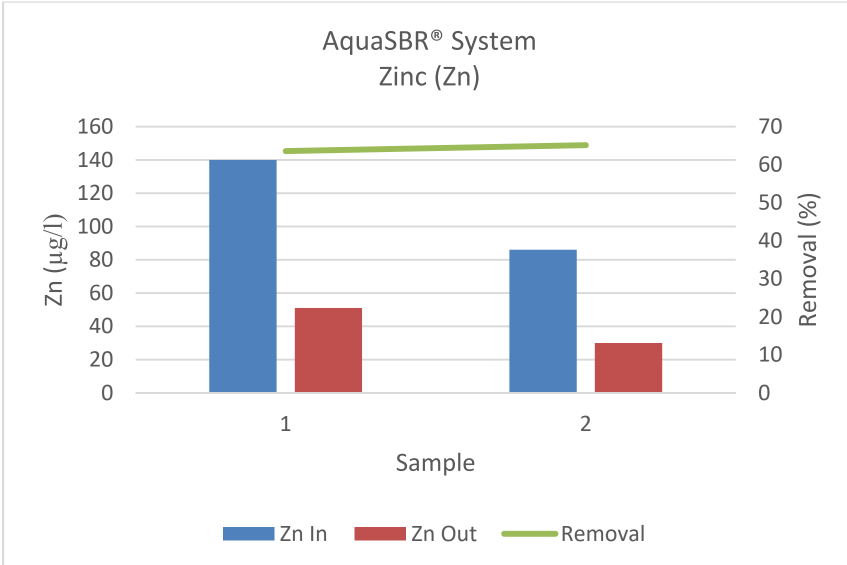

Figure 5: Zinc reduction at AquaSBR installations

Zinc removal across a cloth media filter was tested at three locations and typically showed only between 6 and 10% reduction. In contrast, in the site where polymer was added, Zinc removal was between 15 and 30%.

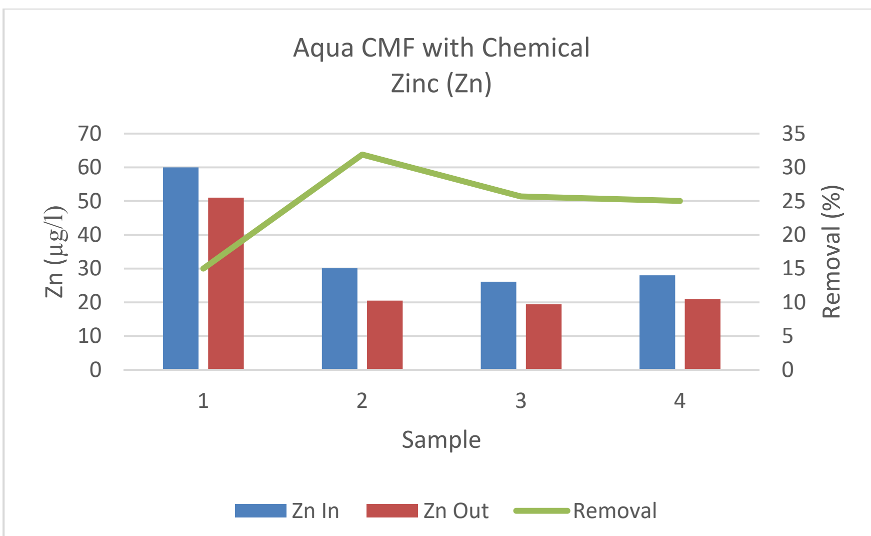

Figure 6: Reduction of Zinc with OptiFiber UFS-9™ media

Additional studies of Zinc removal were performed showing the capabilities of the SBR and filters to removal the particulate and dissolved Zinc. Particulate Zinc was removed well by both systems with removals of approximately 90%. The SBR reduced the dissolved zinc by approximately 47% and as expected, the filter would not remove dissolved Zinc.

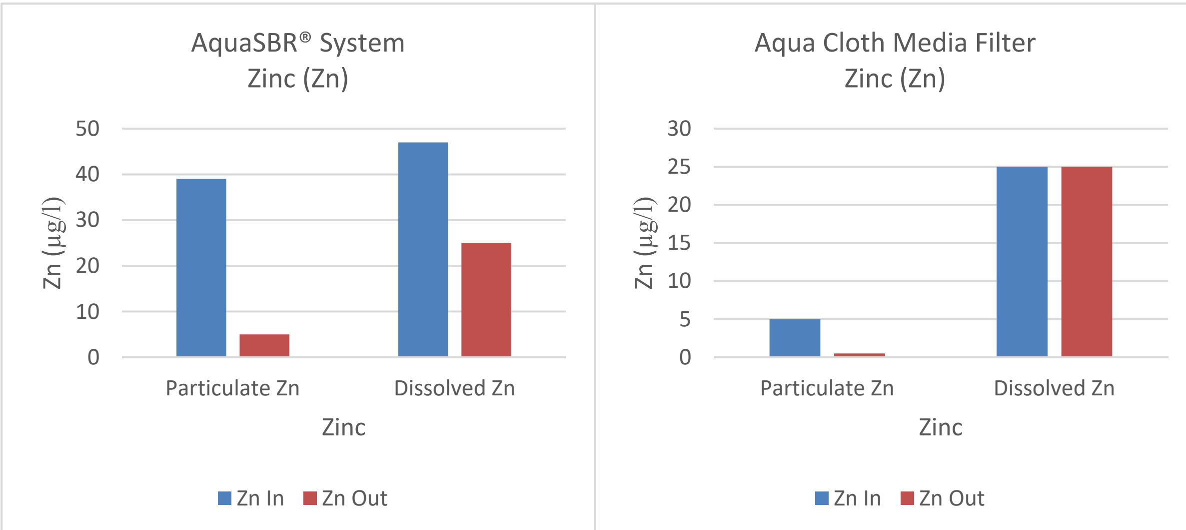

Figure 7: Reduction of Particulate and Dissolved Zinc in an AquaSBR and Cloth Media Filter

Conclusions

Copper, Lead and zinc reduction across SBR systems and cloth media filters was monitored at several locations throughout the United States. The studies demonstrated the extent of metal removal in each system. Recommendations for metal removal can be created based on the study results and the literature review during the study. Below are some lessons learned and recommendations:

Copper:

- Biological Removal: Significant copper reduction was shown across a SBR system with removal values of up to 95%, which was considerably better than the literature review. The lowest value reported out of an SBR system was 2 µg/l, with an average concentration of 5 µg/l.

- Filter Removal: The filter showed removal of up to 50% after the secondary treatment. The lowest value recorded out of the filter was 1 µg/l.

- Chemical Removal: Adjustment of pH to precipitate copper will result on the maximum removal of copper, with solubility of 0.05 mg/l at pH of 8. Metal salt and polymer addition was found to be somewhat helpful on the removal of copper by removing more solids, however, the type of chemical should be carefully selected to make sure it does not contain copper.

Lead:

- Biological removal: For this study, the influent of the plants was too low to determine removal of Lead in the SBR.

- Filtration removal: Filtration showed some signs of lead removal but due to the low influent levels, it was hard to determine the actual removal level.

- Chemical removal: At the levels typically seen in wastewater, precipitation by pH has less of an impact in lead solubility, since at pH of 10, the solubility is 8 mg/l.

Zinc:
- Biological removal: Without modification of the biological system, removals were observed at approximately 65% of total zinc with particulate removals up to 90%.

- Filtration removal: Particulate zinc was removed very efficiently by filtration with up to 90% removal.

- Chemical removal: As the other metals, pH adjustment will contribute to a large portion of zinc removal, at pH of 10, the solubility of zinc is 0.1 mg/l. Polymer addition increased the removal of zinc in the filter by over 50%.

Based on this study, in some cases, biological system alone can achieve the effluent requirement of some of the metals regulated. Depending on the removal level required, biological treatment and filtration, combined with pH adjustment and polymer addition will be needed. Adjustment of pH can be done prior to the biological system if a primary settling step is included. In the biological system the pH can be adjusted to the point that it does not affect treatment (i.e. up to 8.5). Also, pH adjustment can be done prior to filtration.

References

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