

Removal of mercury from biofilms after deliberate contamination of drinking water

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Introduction

Contamination of drinking water by CBRN agents would have major public health, economic and psychosocial consequences. In the production of drinking water distribution system is a highly significant and vulnerable point for contamination. It is known from multiple past experiences that in the distribution system pipe walls, biofilms and deposits are crucial zones of contaminant accumulation. After contaminant detection efficient procedures for decontamination of water and infrastructures are needed to restore the functionality of the distribution system.

Mercury (II) chloride (HgCl_2) is highly toxic chemical which is absorbed from the stomach and intestine and is carried in blood directly to the liver. It accumulates in the kidneys, where it may cause severe damages. HgCl_2 is a widely used industrial chemical in many countries and has high solubility in water. As an elemental salt, Hg^{2+} is not decomposed by e.g. oxidizing agents. Maximum allowed concentration for mercury in drinking water (Council Directive 98/83/EC) is relatively low, 1.0 $\mu\text{g/l}$. These facts make HgCl_2 an ideal target chemical for deliberate contamination of drinking water and distribution systems. Due to chemical stability and high absorption to the surfaces, decontamination has to be performed from a mixture of flushed water and biofilms/ deposits purged out of the distribution systems (by mechanical cleanup methods). This study demonstrates the Hg^{2+} cleanup efficiency from loose, high water content biofilms by different methods.

Materials and Methods

Water-biofilm test solution was produced by letting Kuopio tap water flow through test distribution system made of PEX coupons for 8 weeks. Water-biofilm solution was removed from coupons by shaking with glass pearls for 15 min at 1350 rpm. Twenty ml of purged water-biofilm solution was then spiked with Hg^{2+} to a final concentration of about 50 $\mu\text{g/l}$ and shaken overnight at 50 rpm to equilibrate Hg^{2+} evenly to produce the final test solution.

The actual method of interest was the adsorption of Hg^{2+} to the SAMMS (Self-Assembled Mercaptan on Mesoporous Silica) powder from Steward Advanced Materials Inc. (Chattanooga, TN, USA). SAMMS has specifically designed functional groups that have very high specificity and adsorption capability for mercury.

In addition to SAMMS adsorption, three other methods were also tested, but those served mainly as a reference to the SAMMS. Details of all methods used were:

- 1) Centrifugation of 2ml of test solution for 3 min at 3000 rpm and analysing the supernatant for Hg^{2+} .
- 2) Filtration of 2ml of test solution through 1 ml of sand in a 3 ml glass column and analysing the filtrate for Hg^{2+} .
- 3) Filtration of 2 ml of test solution through 0.45 μm syringe filter (Millipore, Millex-HA) and analysing the filtrate for Hg^{2+} .
- 4) Mixing of 2 ml of test solution with 5 mg of SAMMS in 200 μl of 20% ethanol/water, filtering through the above 0.45 μm syringe filter and analysing the filtrate for Hg^{2+} .

The mercury concentration in treated test solutions was analysed by cold-vapour atomic absorption spectrometry. Removals achieved with different methods were compared to the untreated test solution.

Results and discussion

Centrifugation was not able to sediment Hg^{2+} containing particulate matter, since only 22% of the Hg^{2+} was removed. Cheap and simple sand filtration removed 62% and more efficient syringe filtration 83%. However, both of these simple filtrations are inadequate in real situations. This inadequacy is most likely due to adsorption of Hg^{2+} to very small particles or possibly there is still some fully dissolved Hg^{2+} .

Treatment of test solution with SAMMS-adsorbent resulted in virtually 100% removal of Hg^{2+} . To enable simple removal of SAMMS-powder after adsorption, cotton wool filtration was tested. However, powder leaked through the plug due to small SAMMS particle size of approximately 40 μm . As result, SAMMS treated test solution was filtrated through 0.45 μm pore size filter, which resulted in complete Hg^{2+} removal.

Conclusions

SAMMS+filtration can be used for very effective removal of Hg^{2+} from aqueous slurries resulting in a small final volume of solid waste. Filter pore size has to be small enough for complete SAMMS filtration.

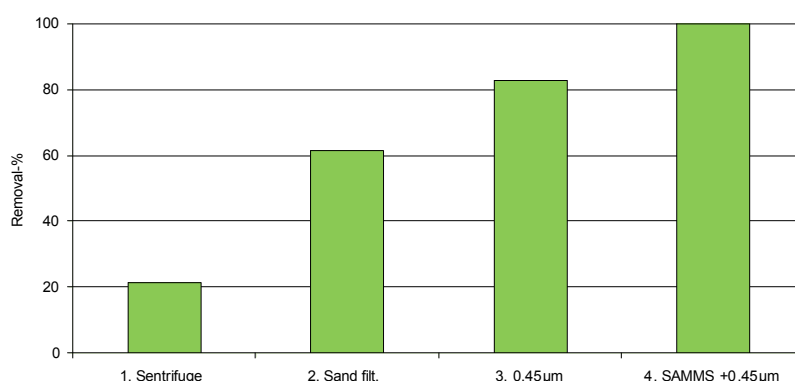


Figure 1. Removal efficiency of different treatment methods relative to no treatment. Methods: 1. Centrifugation for 3min at 3000rpm, 2. Sand filtration 3. Filtration through 0.45 μm syringe filter 4. SAMMS adsorption + filtration of SAMMS powder through 0.45 μm syringe filter

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