Removal of Toxic Heavy Metals by Bacterial Biofilms

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Background

Heavy metals pollution is a major problem when dealing with industrial wastes and should be of great concern [1]. Many methods have been proposed for efficient removal of heavy metals. Biosorption is considered to be one of the relatively new and promising processes in the removal of heavy metals from water and wastewater [2]. Numerous studies have been carried out to create suitable biosorbents for this purpose. One of the examples of common biosorbents are bacteria that, can purify the water by adsorption [3]. This process can be developed through the growth of biofilms on specialized matrices.

The following research monitored the efficacy of *Deinococcus Radiodurans* (DR) in the heavy metal removal.

Goals

- Testing bacterial resistance to heavy metal stress
- Synthesis of a hydrogel surface for biofilm growth by sol-gel method
- Removal of heavy metal by DR biofilms

Methodology

Bacterial growth conditions
- A fresh inoculum of DR bacteria was grown in Tryptone, Glucose, Yeast extract (TGY) media and incubated at 37^0C with shaking.

DR resistance test
- Bacterial resistance was determined by measuring the bacterial growth in liquid media supplemented with different concentrations of heavy metals.

Sol-gel matrix
- The matrix for biofilm growth was developed by using sol-gel technique (Fig.1). TEOS was used as a precursor for condensation and polymerization reactions. 0.01M HCL and 0.1M KOH were used as catalysts in two step procedure.

Adsorption test
- Cd^{2+} removal was tested by exposing sol-gel with and without biofilms to different initial concentrations of heavy metal in distilled water. Heavy metal concentration was measured in distilled water at set time intervals by ICP.

Dead/live cell adsorption
- Sorption method of DR was examined by comparing the adsorption rate of Cd^{2+} ions by the live and dead bacteria.
- Heating at 120^0C was used as a killing method for bacterial cells.

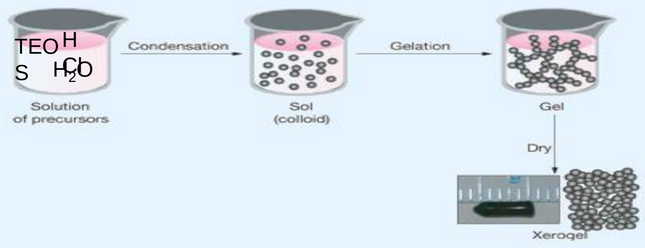

Figure 1. Sol-gel technique for biofilm matrix preparation.

Results

Heavy Metals resistance of Deinococcus Radiodurans

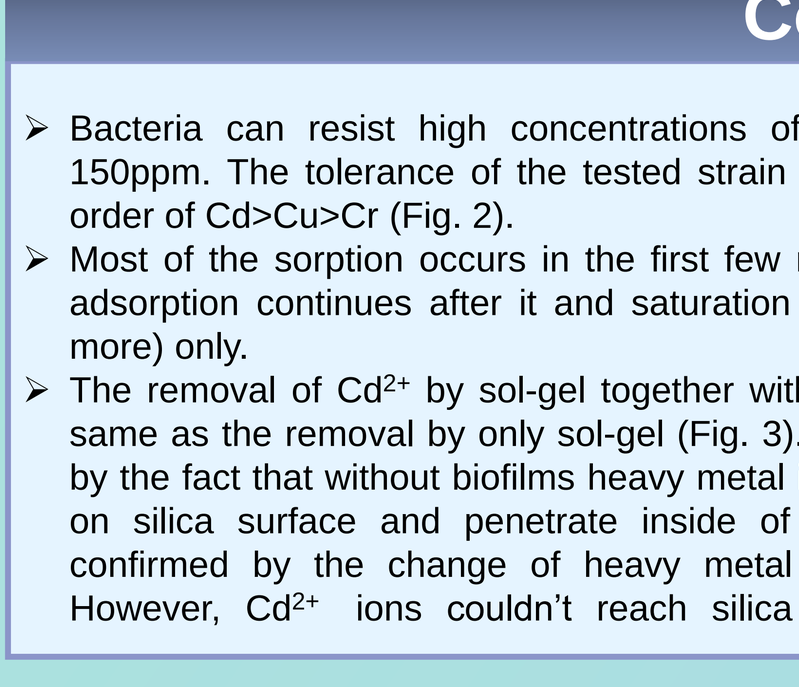

Figure 2. DR resistance to different heavy metal stress.

Cd^{2+} Removal by Biosorption

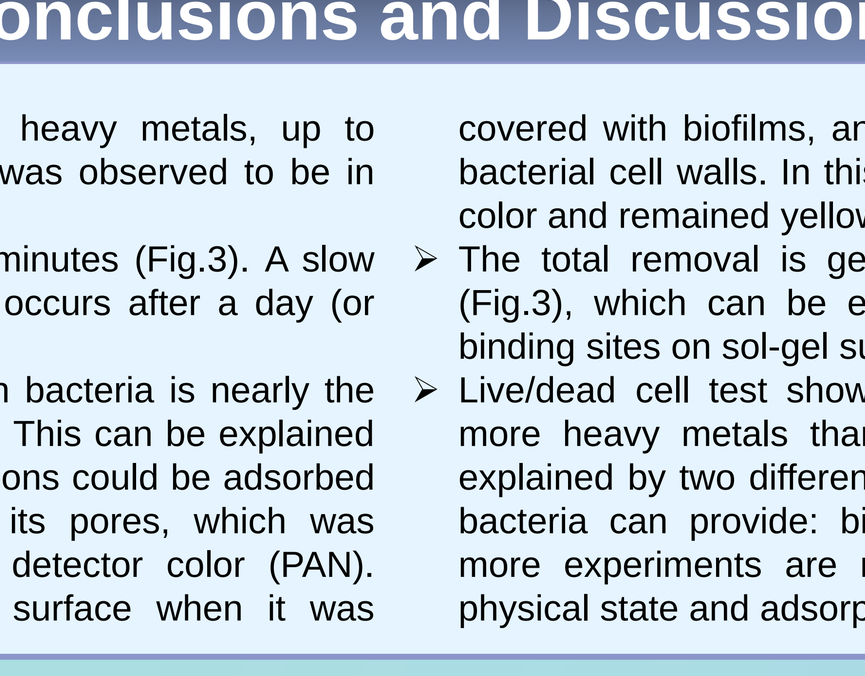

Figure 3. Cd^{2+} sorption on sol-gel matrices with and without biofilm presence.

Adsorption by Dead/Live Bacteria

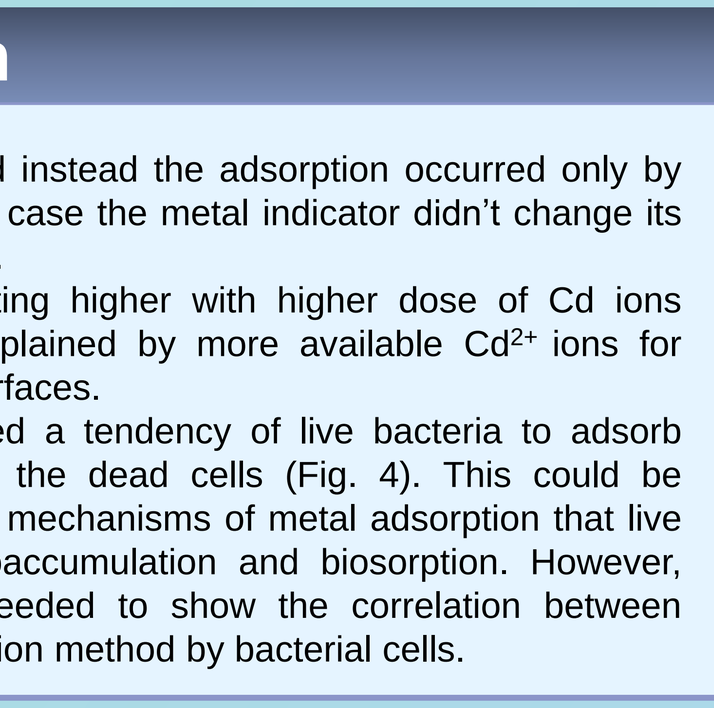

Figure 4. Cd^{2+} sorption by dead and live bacteria at different initial concentrations.

Conclusions and Discussion

- Bacteria can resist high concentrations of heavy metals, up to 150ppm. The tolerance of the tested strain was observed to be in order of Cd>Cu>Cr (Fig. 2).
- Most of the sorption occurs in the first few minutes (Fig.3). A slow adsorption continues after it and saturation occurs after a day (or more) only.
- The removal of Cd^{2+} by sol-gel together with bacteria is nearly the same as the removal by only sol-gel (Fig. 3). This can be explained by the fact that without biofilms heavy metal ions could be adsorbed on silica surface and penetrate inside of its pores, which was confirmed by the change of heavy metal detector color (PAN). However, Cd^{2+} ions couldn't reach silica surface when it was covered with biofilms, and instead the adsorption occurred only by bacterial cell walls. In this case the metal indicator didn't change its color and remained yellow.
- The total removal is getting higher with higher dose of Cd ions (Fig.3), which can be explained by more available Cd^{2+} ions for binding sites on sol-gel surfaces.
- Live/dead cell test showed a tendency of live bacteria to adsorb more heavy metals than the dead cells (Fig. 4). This could be explained by two different mechanisms of metal adsorption that live bacteria can provide: bioaccumulation and biosorption. However, more experiments are needed to show the correlation between physical state and adsorption method by bacterial cells.

Acknowledgments

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