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STUDY OF BIO REMOVAL OF SILVER WASTE USING FUNGAL ISOLATES

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ABSTRACT:

Extensive use of silver has led to serious problems of contamination of terrestrial and aquatic systems. Disposal of silver waste to surface and subsurface waters pose unacceptable health risks. The chief source of silver contamination of water is silver thiosulfate complexes in photographic developing solutions that photofinishers discard directly to sewers. Silver complexed with thiosulfate is difficult to remove from photographic waste. Thus a two stage removal approach was used. Thiosulfate oxidizing bacteria ware initially applied to breakdown the silver thiosulfate complex. The liberated silver is then removed using fungal system. Species of *Mucor*, *Aspergillus* and *Rhizopus* were employed for this. As much as 70% removal of silver is reported here. These findings can help in the development of a green economic process.

KEY WORD: *Silver, Thiosulfate Oxidising Bacteria, Fungi*.

INTRODUCTION:

Historically, silver has been used as coins of trade since 600B.C. ever since its use, silver has found extensive applications ranging from jewellery and silverware to photography and other industries. According to World Silver Survey, produced for The Silver Institute by Thomson Reuters GFMS, annual silver mine production was 761.6 Moz (23, 689 t), the other sources include scrap, disinvestment, government sale and hedging (World Silver Survey, 2012).

Silver is used to make electronic equipment, and dental fillings. It is also used in brazing alloys and solders, to disinfect drinking water and water in swimming pools, as an antibacterial agent. Silver has been used in lozenges and chewing gum to help people stop smoking (ATSDR, 2012). Silver based compounds are one of the main antimicrobials used in textiles. (Windler, L. *et al*, 2013).

Silver has been characterized as Toxic substance and the affected organ systems are identified as Renal (Urinary system and kidneys) and Reproductive system (Producing Children) (ATSDR, 2012).

The atmosphere receives 300 tonnes of silver each year from a variety of sources. Presence of silver is a serious threat to human health. There is a highly toxic effect of silver on several parts of cells, such as proteins, nucleic acids and riboflavin. Studies in rats have revealed the data that concentrations in the range of 0.4 to 1.0 mg/l have caused pathogenic changes in the kidneys, liver and spleen (Smith and Carson, 1977).

With the increased use of this metal in various processes, it's concentration in the waste produced has also increased. Thus the need to develop methods for efficient and environmentally safe silver removal has gained more importance. With the ever increasing price of this metal the need for its efficient use and recovery is even more pressing. Chemical methods though have the efficiency, they lack the safety concern as the recovery methods themselves generate waste that needs to be taken care of, and microbial methods provide safe alternatives to the removal and thus recovery of this precious metal from waste. Although a very large drop of silver demand is recorded in photography due to digital solutions, an increase of its demand is observed in the use of printed circuit boards. Thus the need for developing approaches for safe and efficient alternative methods for its removal from waste stands justified.

Microorganisms are useful in removal of silver from waste, the various processes useful in this are bioaccumulation, biosorption, siderophore interaction, enzyme mediated transformations, polymer binding and transport and metabolite solubilization and immobilization (Ford and Mitchell, 1992).

This has led to the development of technology for its removal from waste. Silver complexed with thiosulfate is difficult to remove from photographic waste. A two stage removal of silver from such waste is reported here. Thiosulfate oxidizing bacteria were initially applied to break down the silver thiosulfate complex. The liberated silver is then removed using fungal system. Species of *Mucor*, *Aspergillus* and *Rhizopus* were employed for the removal of silver from silver waste.

MATERIALS AND METHODS:

Organisms, growth and harvesting of biomass

Thiosulfate oxidizing bacteria isolated previously and maintained on Starky's medium were grown on Starky's medium for 5 days on a rotary shaker. The organisms were found to be tolerant to 200 mgl^{-1} silver as evidenced from its growth in a medium supplemented with silver nitrate (200 mg silver l^{-1}) (Starkey R,L., 1935).

Isolation of fungi was carried from garden soil on Potato dextrose agar and three species were identified with cultural and microscopic characteristics as *Mucor, Aspergillus and Rhizopus* the biomass was collected by growing the species on potato dextrose broth and filtered with Whatman filter no. 1, washed with de-ionized distilled water and dried (Naseem, *et.al;* 1995).

Photo film processing Waste Water

Used photographic film fixer solution i.e. UFFS was procured from a local film processing unit. It contained very high amount of silver up to $1.6gl^{-1}$ and thiosulfate concentration was $21.2gl^{-1}$. The UFFS was diluted 1:10 times so as to bring the thiosulfate concentration in a range suitable for growth of thiosulfate oxidizing bacteria.

Biodegradation of thiosulfate from UFFS

Culture of thiosulfate oxidizing bacteria (25 ml containing 10^7 cells/ml) was inoculated into 1:10 diluted UFFS (250 ml, pH 6.5) and incubated at ambient temperature (Ca 30 °C) at 120 rpm. After incubation of 5 days, the medium was centrifuged at 10,000 rpm for 20 min to remove bacteria and insoluble particulate matter (Bard *et.al.*, 1976).

The supernatant was analyzed for thiosulfate content, uninoculated UFFS was used as control in the experiment.

Analysis

Thiosulfate concentration was determined by iodometric method. Silver was estimated by atomic absorption spectrometry (ELICO SL-194) with air acetylene flame at λ =328.1 nm). After biodegradation of thiosulfate from UFFS any precipitated sulfur was removed by filtration and the supernatant used in silver biosorption experiment (APHA, 1992).

Shake flask experiment for removal of silver from UFFS.

Untreated and treated UFFS were further used for silver removal by biosorption using the fungal biomass of *Mucor*, *Aspergillus* and *Rhizopus*. Different concentration of biomass were added to 100 ml UFFS for varying contact periods in a rotary shaker at ambient temperature at 120 rpm. (Pethkar et.al., 2003).

After contact period, the biomass was removed by centrifugation at 10,000 rpm for 10 min. the silver content of remaining UFFS was determined.

RESULTS:

No significant biosorption of silver from untreated UFFS was observed using the three fungal biomass of *Mucor*, *Aspergillus* and *Rhizopus*.

Thiosulfate was completely oxidized by thiosulfate oxidizing bacteria and no thiosulfate was detected in treated fixer solution (Fig-1).

No significant biosorption of silver from untreated UFFS was observed using the three fungal biomass of *Mucor*, *Aspergillus* and *Rhizopus*.

Biosorption of silver was observed from treated UFFS using the fungal biomass. Among the three species used for the study *Rhizopus*spp. showed highest biosorption of 55%. The species of *Mucor*, *Aspergillus* showed 49% and 48% biosorption respectively. (Fig-2)

Further analysis using the species of *Rhizopus*showed the amount of biosorbent required for maximum silver biosorption was 5.5% as seen in (Fig-3).

Further increase in the biosorbent concentration did not increase the biosorption efficiency.

The contact time required for silver sorption was 30min. (Fig-4).

DISCUSSION:

The experimental observation suggests that silver complexed with thiosulfate is very difficult to remove from photographic waste. A two-stage removal of silver from such waste is necessary for efficient recovery. A comparative evaluation of three species of fungi showed that fungi are a good potential for removal of silver from photographic waste like UFFS. Further up scaling it to a sufficient level can help in the development of a green economic process.

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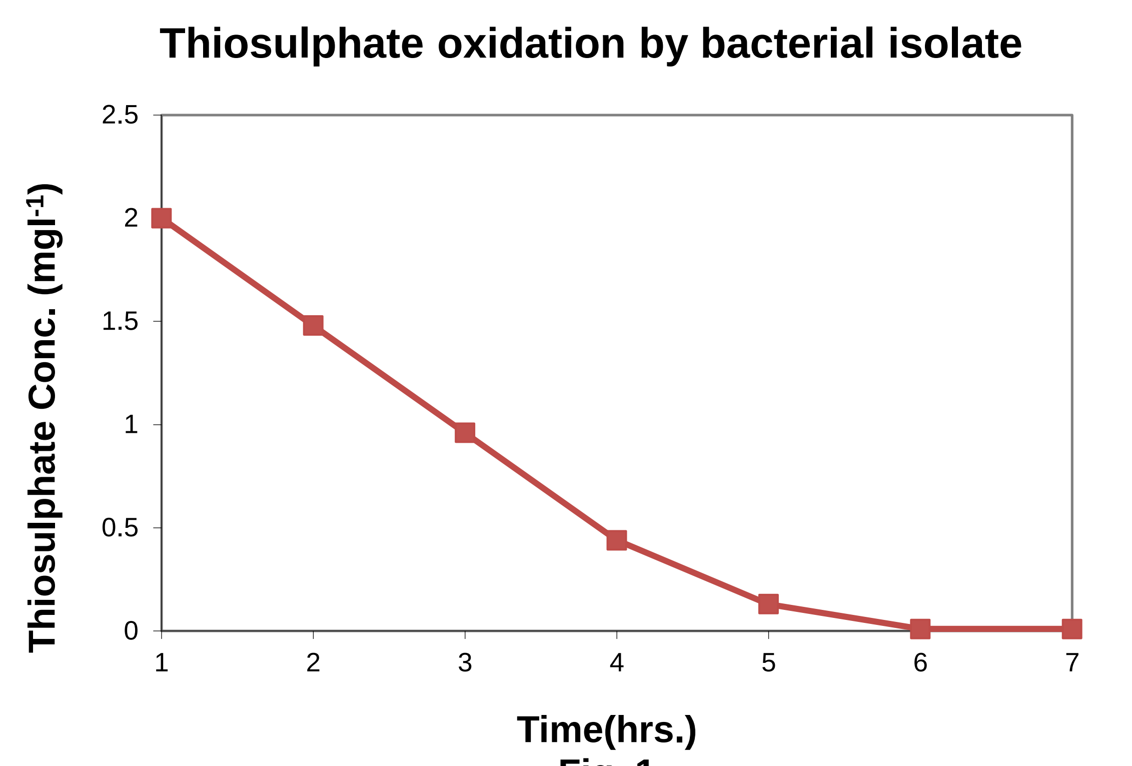

Fig. 1

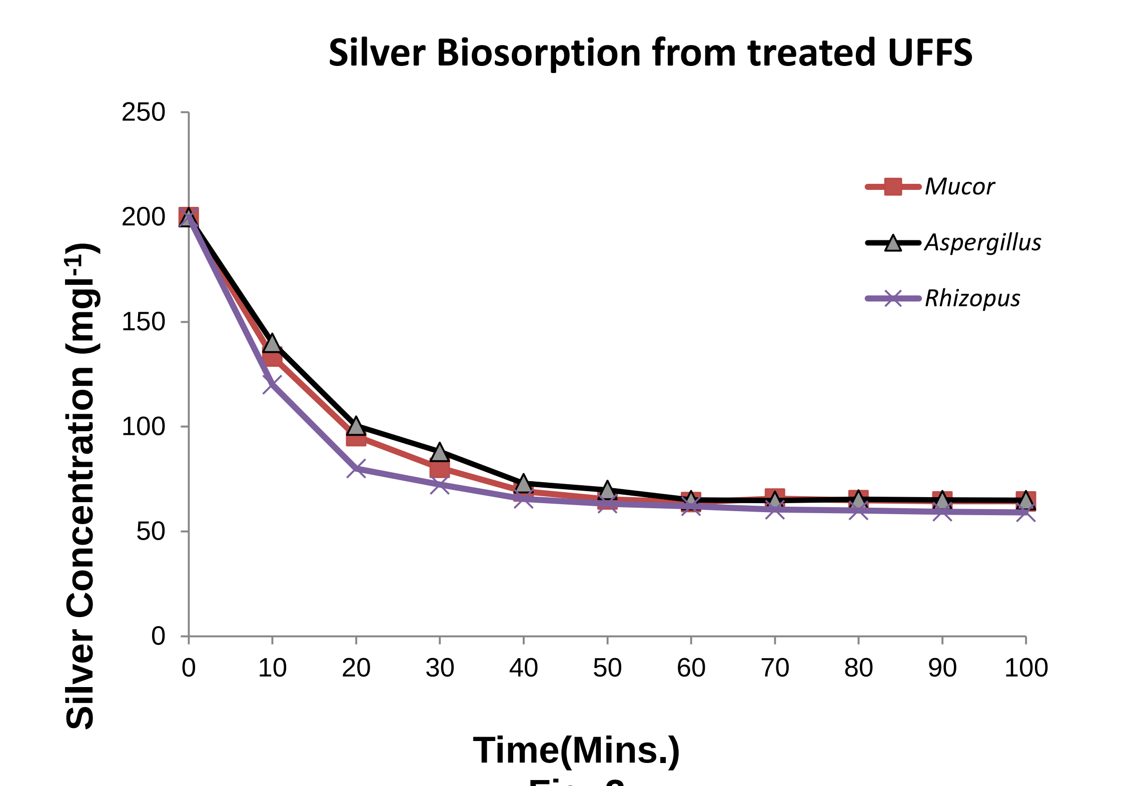
Silver Biosorption from treated UFFS
Silver Concentration (mgl-1)
Time(Mins.)
Mucor
Aspergillus
Rhizopus
0
50
100
150
200
250
0
10
20
30
40
50
60
70
80
90
100

Fig. 2

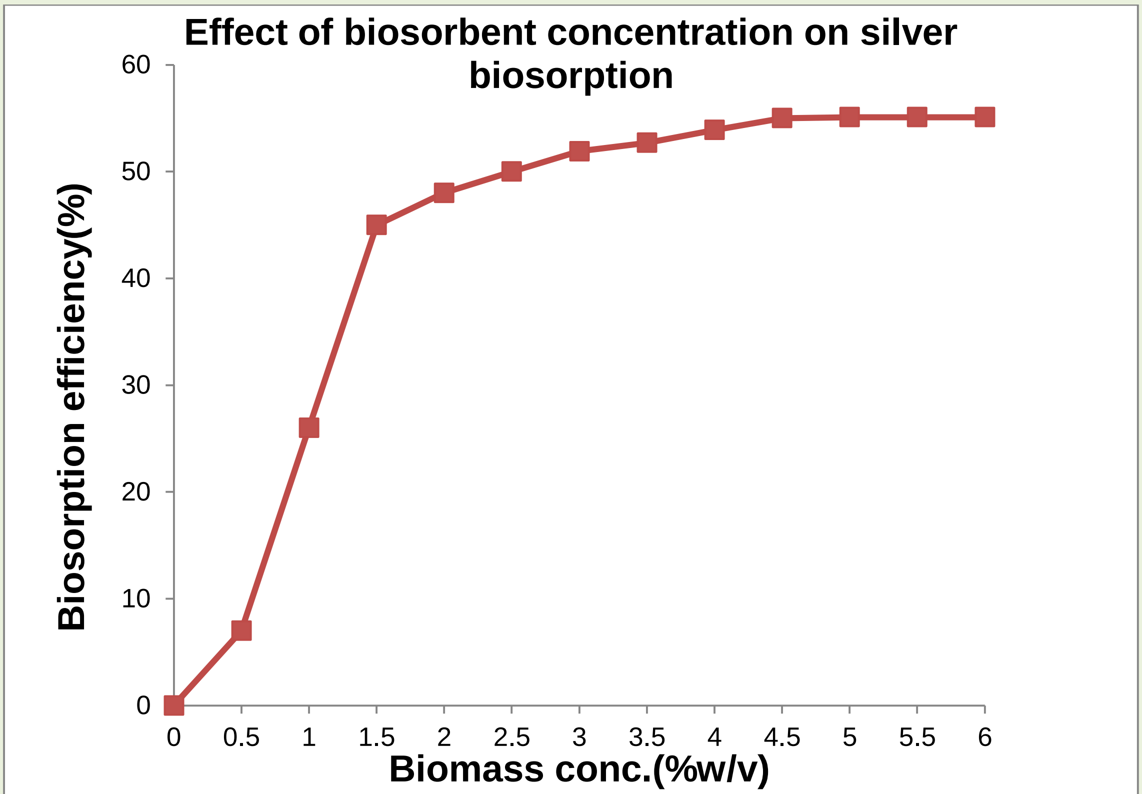
Effect of biosorbent concentration on silver biosorption
Biosorption efficiency(%)
Biomass conc.(%w/v)
0
10
20
30
40
50
60
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6

Fig. 3

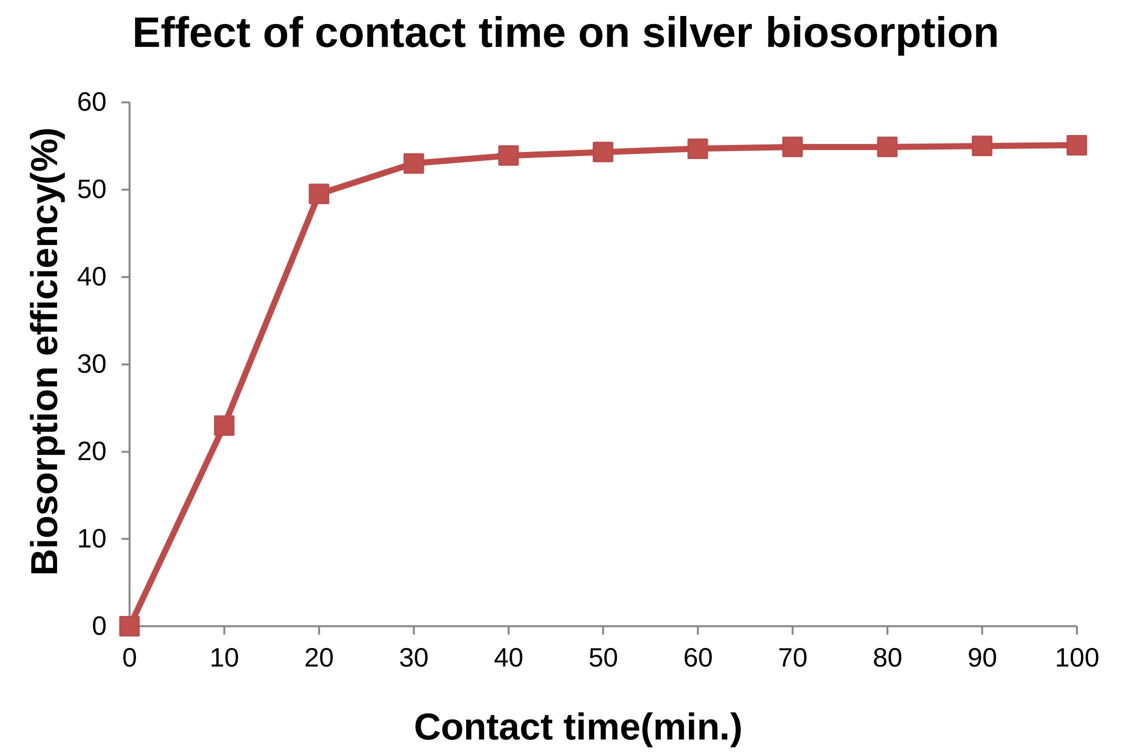
Effect of contact time on silver biosorption
Biosorption efficiency(%)
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Contact time(min.)

Fig. 4