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EFFECTIVE BIODEGRADATION OF FLUORO SURFACTANT AND SODIUM DODECYL SULPHATE (SDS) FROM INDUSTRIAL EFFLUENTS BY USING THREE STAGE BIOREACTOR

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Abstract

Organic surface active agents like Fluoro surfactant and SDS are widely used in aqueous film forming foam (AFFF), detergent and cosmetic product formulations and they contribute significantly to the pollution profile of Industrial waste waters. Screening of Fluro surfactant and SDS degradation by using microorganism was carried out by the soil enrichment technique. The reduction of Fluro surfactant and SDS and COD in the synthetic wastewater by free cells of the Micro Organism was investigated. Free cells could degrade it up to 80± 2% of the 2400 mg/litre Surfactant and 70 ± 4 % COD in the synthetic waste water at a residence time of 24 hours . The treatment of synthetic effluent with the application of the three stage bioreactor, involving aeration, adsorption with low cost scrap rubber granules and treatment with immobilized Pseudomonas aeruginosa. The three stage bioreactor showed an increase in the Surfactant elimination from 81 ± 2% to 99.8± 0.1 % and COD reduction from 70 ± 1 % to 99 ± 1 % at a residence time of 24 hours in continuous treatment. The simplicity of the technique makes the process quite acceptable for industrial applications.

Keywords: Fluro Surfactant, Aqueous Film Forming Foam, Sodium Dodecyl Sulphate, Pseudomonas Aeruginosa, Three Stage Bioreactor, Scrap Granular Rubber, Immobilized Cells.

Introduction

Surfactants are organic compounds that reduce surface tension in water and other liquids (Kowalskaet al .2004).In the Industrial wastewater produced by the Industry and households, surfactants are invariably exist in significant amounts. Surfactants have also been widely used in Aqueous film forming foam, textiles, fibers, paints, polymers, cosmetics, pharmaceuticals, mining, and oil recovery and paper industry. These applications of the surfactant resulting in their increased discharge into the wastewater produce foam and enter into the underground water resources. This constitute an ecological risk for aquatic organisms (Nasiruddin and Uzva , 2005). According to the charge of their hydrophilic moiety, surfactants can be classified into four categories: anionic, non-ionic, cationic and amphoteric (Moziaet al . 2005).Sodium Dodecyl Sulfate (SDS) selected for the present study is an example of anionic linear alkyl sulfate (Adacet al. 2005).

Surfactant biodegradation has been the subject of substantial research since the 1950s when synthetic detergents came into widespread use. One such factor, particularly important in surfactant based processes, is the high concentration of surfactants involved. It is well documented that most commercial surfactants at low concentration range undergo and extensive biodegradation where that at higher concentration rarely undergo rapid degradation in an aerobic environment. But surfactants at much higher concentrations are commonly encountered in soil washing and other surfactant-based remediation technologies.

To improve the biodegradation of surfactants at higher concentration, biotechnological approaches may be applied to bring out efficient solutions for biological cleanup of industrial and domestic wastewater. In order to increase bacterial concentration in the bulk solution and to enhance biodegradation rates, membrane bioreactors have been successfully used by many investigators. (Mortazavi et al.2008). This work has been carried out with an objective of developing a suitable bioprocess for the effective biodegradation of fluoro surfactant and SDS at high concentration.

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Materials and Methods

Identification of SDS Degrading Bacteria

Soil samples were collected from aqueous film forming foam and detergent contaminated area. In the present study soil enrichment method was used to isolate SDS degrading organism. Isolation was done by enrichment of the soil extract progressively with SDS. All the strains isolated at the final SDS concentration of (2400 mg/litre) were again subjected to enrichment with SDS in mineral salt SDS medium (MSSM). Incubation was carried out at room temperature (30 ± 2 ^{0}C) for 24 hours. At the final concentration of 2100mg/litre of SDS there was only 9 strains that could grow in MSSM and the most efficient strain giving maximum SDS removal at minimum time was selected. MBAS assay (Hayashi, 1976) and HPLC (Hosseini et al.,2010) were used for the determination of SDS reduction.

Synthetic Wastewater Composition

Composition of synthetic wastewater was (mg/litre) SDS - 2400; fluorosurfactant-1100, $(NH_4)_2SO4$ - 125; MgSO4. $7H_2O$ - 25; $FeCl_3.6H_2O$ - 0.125; $CaCl_2$ - 1.825; KH_2PO_4 - 131.75; K_2HPO_4 -267; $MnSO_4.H_2O$ - 267; starch -100. pH- 7.2. COD -800 mg/ liter and BOD-200 mg/liter

Treatment of Synthetic Wastewater with Free Cells

Cells were collected as per the procedure mentioned above. These cells were inoculated in synthetic wastewater and checked its performance in reducing SDS and COD. HPLC were used for the determination of SDS reduction.COD was checked by standard methods (APHA, 1995) .

Treatment of synthetic wastewater with bioreactor

The three stage bioreactor was used for the treatment of synthetic wastewater. The bioreactor was capable of offering treatment in three stages such as aeration, physical adsorption and bacterial treatment. The effluent passed from the bottom of the bioreactor rose through the first reactor (reactor for aeration) and then slowly rose through the scrap granular rubber adsorbent (SGR) in the second stage of the reactor. Finally it went through the immobilized cells packed column in the third stage of the reactor. The bioreactor experiment was conducted at different flow rates of 5ml/hour, 7ml/hour, 9ml/hour and 10ml/hour with a peristaltic pump (Pharmacia). Performance of bioreactor was evaluated at individual stage and combined stage by analyzing with HPLC for the determination of SDS reduction. COD was checked by standard methods.

Result and Discussion

Microorganisms Pseudomonas aeruginosa was isolated from a fluoro surfactant and detergent contaminated soil. The isolate was capable of degrading 80± 2% of SDS and 70 ± 4 % COD at 24 hours of incubation period. The optimum condition for degradation was 37^{0}c and pH 7.5.

The strain was able to retain the biodegradation ability after depletion of surfactants for 16 days. The characteristics of wastewater released from industry vary with the type of treatment plant, sampling time and process condition. Hence the present study was carried out with synthetic detergent wastewater having SDS concentration 2400 mg/liter, 800 mg/ liter COD and 200 mg/liter BOD. By taking these factors into consideration an attempt was made to the effective treatment of synthetic surfactant wastewater with a suitable adsorbent and bacterial cell in bioreactor.

The synthetic wastewater was treated with free cells of Pseudomonas aeruginosa and the degradation of the synthetic wastewater revealed that 80± 2 % SDS and 70 ± 4 % COD reduction was affected by 24 hours of treatment.

Scrap granular rubber (SGR) and active carbon were studied for evaluating their adsorption capacity of SDS in the synthetic wastewater. The capacity for SGR for the reduction of SDS and COD were 30 % and 10 % respectively at a flow rate of 5ml/hour. This SGR was the waste product of tyres, locally purchased at the cost of Rs. 10 per kg . The enormous amount of waste tyres, accumulated in the environment. Tyre, contains 25-30% by weight carbon black as reinforcing filler. Its hydroxyl and/or carboxyl group are responsible for the high degree of adsorption. (Paritoshet al. 2003). It was observed that 30% adsorption of SDS occurred within 5 hours of wastewater treatment.

In the three stage reactor the effluent was treated with air at first, then with SGR adsorbent packed reactor, finally with an immobilized cell packed column. Performance of each stage was evaluated individually at different flow rates. 5ml/hour showed a better performance. (fig : 2) However on increasing the flow rate from 5ml/hour to 10ml/hour both the SDS and COD reduction rate progressively got reduced.

The first reactor, aeration enhanced the biodegradation (8% and 7% reduction of SDS and COD respectively occurred at a flow rate of 5 ml/hour). 2^{nd} reactor was used for treating the waste water with SGR leads to adsorb SDS because of its better adsorption efficiency (30 ± 2%). After the treatment of effluent in the first and second reactor, the total removal of SDS and COD was 38 ± 2% and 35 ± 2% respectively. Therefore the third stage (immobilized cells packed) reactor received the synthetic wastewater with the concentration of 1488 mg/litre (5.15Mm

Hence the three stage reactor system could exhibit a better efficiency than when it was used as a single system for the treatment of the wastewater. It brings the removal of SDS to 99.8 ± 0.1% and COD to99 ± 0.9%, respectively.

Conclusions
A high concentration of surfactant in fire fighting chemicals, detergents and cosmetic industry wastewater significantly inhibits microbial growth and produces foam. These two phenomena are very problematic and require judicious intervention in order to reduce their impact on the good running of the industrial wastewater treatment.

In this study, the integration of aeration permitted with adsorption by very low-cost scrap rubber in the form of granules and treatment of immobilized cells of bacterium (Pseudomonas aeruginosa) with an efficient SDS degradation spectrum showed better degradation kinetics in the three stage bioreactor than with the conventional biological systems. It shows the enhancement of SDS degradation rate from 81± 2% to 99.8 ± 0.1 %and COD reduction from 70 ± 1 % to 99 ± 1 % at a residence time of 24 hours. The simplicity of the technique makes the process quite acceptable and the results of this study suggest that the usage of three stage bioreactor in industrial sewage can be a cost effective method.

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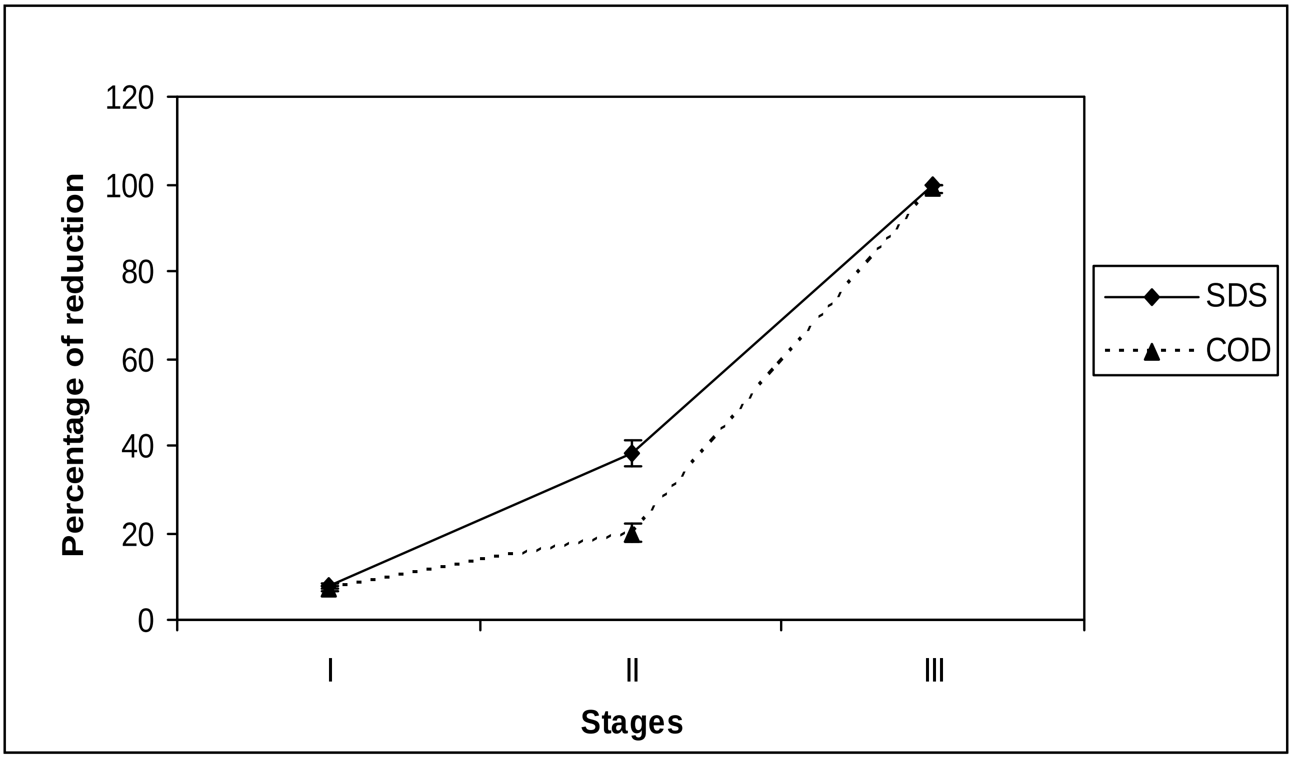
Table: I: Effect On The Biodegradation of SDS And Reduction of COD By Single Stage Free Cells And Three Stage Packed Bed Reactor

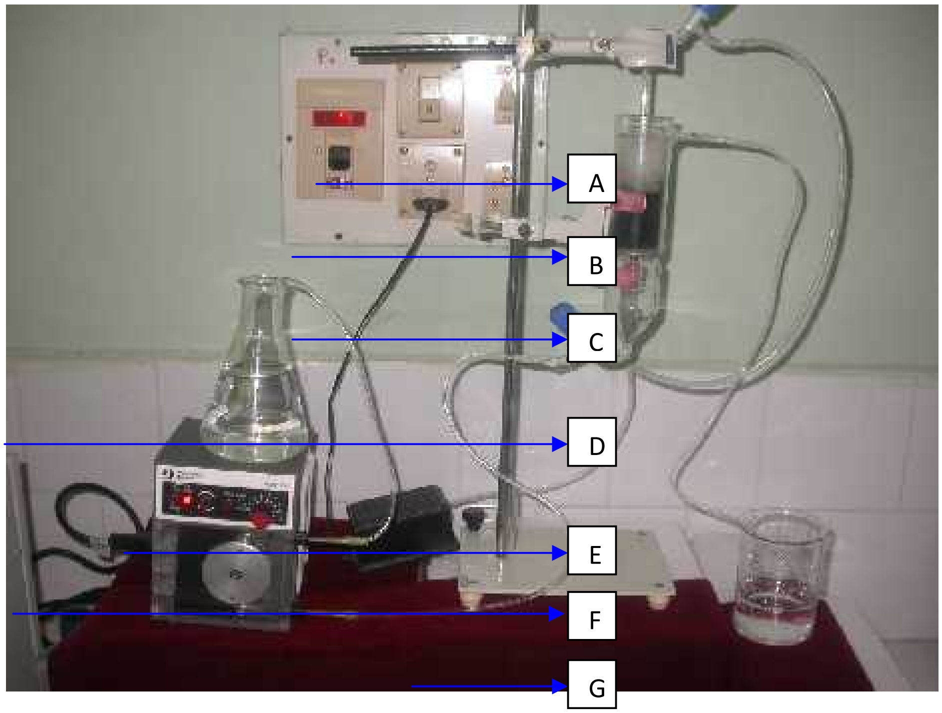
Sr.No.	Mode of Treatment	% Degradation of SDS	% Reduction of COD
1	With Single stage free cells	80 ± 2%	70 ± 4%
2	With Three stage packed bed reactor	99.8 ± 0.1%	99 ± 0.9%,

Fig: 1: Continuous Treatment of synthetic wastewater with three stage packed bed reactor at a flow rate 5ml/hour



1 Stage: - Treatment with air
2 Stage: - Treatment with scrap granular rubber
3 Stage: - Treatment with immobilized cells

Fig : 2: Treatment of Wastewater With Aerobic Three Stage Reactor



A ⟶ **Third stage column (Immobilized cells**).

B ⟶ **Second stage column (Scrap granular rubber).**

C ⟶ **First stage column (Air).**

D ⟶ **Synthetic waste water for treatment.**

E ⟶ **Air pump.**

F ⟶ **Peristaltic pump.**

G ⟶ **Treated synthetic waste water.**