EVALUATION OF CARBON SOURCES TO AUGMENT SULFATE-REDUCING ACTIVITY FOR REMOVAL OF Cd (II) FROM SIMULATED WASTEWATER

Environmental Science

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ABSTRACT Recently a promising class of microbes, sulfate reducing bacteria (SRB) has gained widespread consideration as an alternative remediation tool, to precipitate heavy metals using H2S, which is produced biologically by SRB. In this attempt, influence of some carbon sources on the growth and activity of SRB were studied. Experiment was conducted to investigate the best carbon source for development of sulphate reducing bacteria for removal of Cd (II) and COD from simulated wastewater. Minimum inhibitory concentration (MIC) for Cd (II) was determined to be 40 mg/L. Effect of various carbon sources (Lactose, Sucrose, Glucose, Lactate) were studied on removal of Cd (II) and COD. Maximum Cd (II) and COD removal was found to be 80.3% and 75.5% respectively at initial concentration of 40 mg/L Cd (II) using lactate as carbon source in maximum retention period of 7 days. From these results we can conclude that utilization of SRB would be a feasible method for treatment of heavy metals contaminated wastewater.

1. INTRODUCTION

Cadmium (II) is a extremely noxious element and is hazardous to living organisms. Cadmium cannot be biodegraded and because of anthropogenic activities its concentration is progressively increasing in the environment (Peng et al., 2012). The chief sources of cadmium are metal plating, smelting, mining, ceramics, metallurgical alloying, erosion of natural deposits, discharge from metal refineries, runoff from waste batteries, and refining of non-ferrous metals, manufacturing of phosphate fertilisers, recycling of cadmium plated steel scrap, pigment manufacture, printing and the photographic industry. (Hutton et al., 1987; Nriagu and Pacyna, 1988; Friberg et al.,1992). Cadmium is repetitively dispersed among three main environmental components: air, water, and soil. (Khairy et al., 2014). Cadmium ions being non biodegradable, build up in living organisms, causing various disorders (Hardman et al., 1993; Nogaw and Kido, 1996).

Cd is first and foremost toxic to the kidney and it enters body mainly through the oral route (Friberg et al., 1992). Human exposure to cadmium cause genomic instability through complex and multifactorial mechanisms, including proteinuria, a decrease in glomerular filtration rate, and an increase in the frequency of kidney-stone formation that leads to various types of cancer, bone demineralisation, either through direct bone damage or indirectly as a result of renal dysfunction and higher dose of Cadmium cause spilling of proteins in the urine and disruption of potassium metabolism (Bernard, 2008; Mathialagan and Viraraghavan, 2002; Purkayastha, 2014; Khairy et al., 2014).

The World Health Organization, US Environmental Protection agency, and the EU Directive have set 0.005 mg/L as the maximum cadmium(II) concentration level in domestic water supplies (Goel et al., 2006; Peng et al., 2007; Taki et al., 2008; Cheng et al., 2008; Khairy et al., 2014). Moreover, IS 10500 has set the maximum permissible limit of Cd in drinking water as 0.003 mg/L. (BIS, 2012; Purkayastha et al., 2014).

The conventional physicochemical technologies such as precipitation, filtration, ion exchange, membrane separation, electrochemical treatment, oxidation–reduction and electron-deposition were proved to be insufficient or expensive for removing metals from aqueous solutions at lower concentrations. (Bai et al., 2008; Purkayastha et al., 2014). There are some disadvantages linked with these methods e.g. they are more costly compared to biological treatment methods and can also produce other waste problems and has restricted their industrial applications (Ong et al., 2005; Malakahmad et al., 2011).

Now a days, anaerobic techniques are becoming progressively more important and intensively studied as they are environmentally safe and cost-effective. Biological treatment with sulphate reducing bacteria (SRB) has been applied as the most promising alternative for the treatment of several types of wastewaters. As a bioremediation strategy, the potential advantages of metal sulfide precipitation include production of lower sludge volume and lower solubility products as compared with carbonate, hydroxide and phosphate precipitation (Podda et al., 2000; Allan et al., 2002; Bai et al., 2008). The present study aims at study of minimum inhibitory concentration of Cd (II) and influence of different carbon substrates on growth and activity of sulfate reducing bacteria for efficient removal of Cd (II) from simulated waste water.

2. MATERIALS AND METHODS
2.1. SOURCE OF SRB CONSORTIUM

Activated sludge was collected from an electroplating industry LPS Rohtak, Haryana, India. The sludge was filtered using coarse screen and incubated in anaerobic conditions to enrich sulfate reducing consortium for two months in Postgate growth medium with composition (g/L): KH_2PO_4 0.5; Na_2SO_4 1.0; NH_4Cl 2.0; $CaCl_2$ 0.06; $FeSO_4$ 0.005; sodium citrate 0.3; yeast extract 0.1; sodium lactate 15 ml.. The pH of the medium was adjusted to 7.5 by 1 M HCl or 1 M NaOH. Incubations were performed at 37◦C in the dark. All chemicals were analytical grade and solutions were prepared with sterile deionized water.

2.2. MIC DETERMINATION

Minimum Inhibitory Concentration (MIC) of Cd (II) ions was determined for sulfate reducing bacterial consortium. Cadmium sulfate ($CdSO_4$; 2.28 g) was dissolved in double distilled water (1 litre) to obtain Cd (II) solution at 1000 mg/L. It was used as stock solution. Cd (II) was varied in concentration ranging from 10 to 80 mg/L. Optical density (OD), protein content and metal removal (%) were detected to find out the minimum inhibitory concentration of Cd (II) ions. Determination of protein was done by Lowry's Method and OD was measured at λmax 600 nm by UV-Visible Spectrophotometer (T80 UV/VIS).

2.3. EXPERIMENTAL METHODS

Experiments were carried out in 120 mL serum vials in batch mode using 100 mL of modified postgate growth medium with pH 7 and were sealed with butyl rubber stoppers and aluminum crimps. After that 2 mL supernatant of SRB (5,000 mg/L VSS) was injected in serum vials and were incubated at 37°C in static position. Nitrogen gas was added to the vials with help of syringe so as to establish the anaerobic environment. Different carbon sources such as lactose, sucrose, glucose and sodium lactate were optimized using modified postgate growth medium to determine best carbon substrate for anaerobic sulphate reduction. 3.0% of total carbon content was added from all the selected carbon sources. All experiments were conducted in triplicate and average values were determined.

3. RESULTS AND DISCUSSION

3.1 DETERMINATION OF MIC

The minimum inhibitory concentration (MIC) of Cd (II) ions for sulfate reducing bacterial consortium was analysed using different concentration of heavy metal ranging from 10 to 80 mg/L amended in postgate growth medium. The incubation of cultures was performed at 37°C for a period of 7 days to examine growth of SRB consortium. On 40 ppm concentration of Cd (II) ions, maximum OD, protein content and Cd (II) sequestration was found to be 0.98, 0.62 mg/mL and 95.9%, respectively as shown in Fig.1. So MIC of Cd (II) ions for the said consortium was found to be to be 40 ppm.
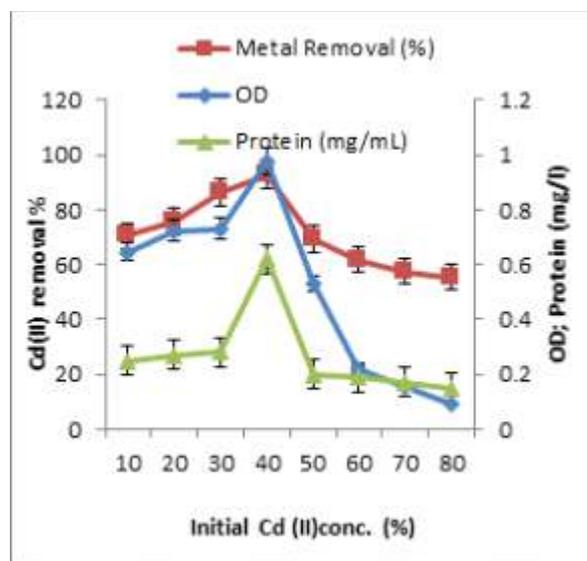

Fig. 1 Determination of MIC for Cd (II) at pH 7 and temperature = 37 °C and contact time = 7 days

3.2 OPTIMIZATION OF CARBON SOURCE

The modified Postgate growth medium was tested by varying different carbon sources such as lactose, sucrose, glucose and sodium lactate each with 3.0 % carbon content and with 40 ppm Cd (II) concentration. Experiments were conducted to compare the pH profile, ORP (oxidation reduction potential), soluble COD removal and Cd (II) removal efficiency in presence of four carbon sources (Fig. 2). The lowest Cd (II) removal 44.2%, 59.4% and 68.8% was obtained with lactose, sucrose and glucose respectively. The substrate lactose, sucrose and glucose were fermented and assisted the fermentative bacteria as compared to sulfate reducing bacteria. Thus fructose, sucrose and glucose resulted in reduction in pH of media and developed acidic conditions. This confirmed that fermentation had occurred when the consortium was supplemented with these carbon sources. The maximum Cd (II) removal achieved was 80.3% with sodium lactate as carbon source. So it can be concluded that when sodium lactate was used as a carbon source at temperature 37°C and time 7 days, maximum ORP, pH and soluble COD removal attained were -289, 7.15, and 75.5% respectively. So sodium lactate was considered to be the most efficient carbon source for the said sulfate reducing bacterial consortium.
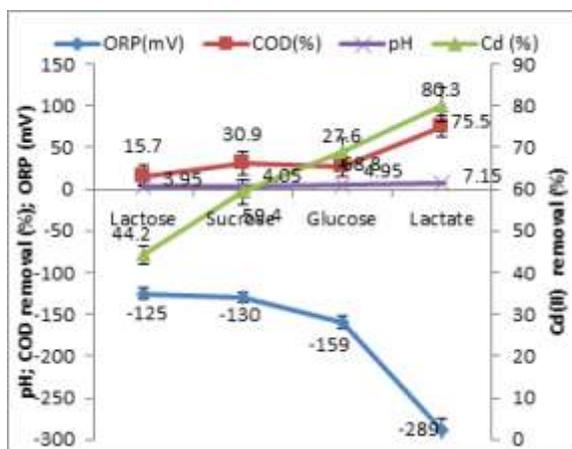

Fig. 2 Effect of carbon sources on various parameters at temperature = 37 °C and contact time = 7 days

4. CONCLUSION

In this study, Mimimum inhibitory Concentration (MIC) of Cd (II) ions was found to be 40 ppm. The maximum responses were found to be -289, ORP, 7.15, pH and 75.5% COD and 80.3% Cd (II) removal respectively at pH 7, temperature 37oC and incubation time 7 days. This study concluded that sodium lactate was found to be the best carbon substrate for removal of Cd (II) from simulated waste water.

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