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Sulfur Recovery using Single Chambered Electrolytic Cell Accompanied by Different Potential Difference

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Abstract: ***Performance of two different half cells(anaerobic digester) made in 500 ml beakers having an effective anodic chamber volume of 450 ml were evaluated under the effect of an applied potential difference of the range -0.3 V to + 0.3 V. Synthetic feed containing sulfide was used to study the amount of sulfur recovered after an electrochemical process had taken place.***

Keywords: Microbial Fuel cell, Graphite felt, Wastewater treatment, Anaerobic sulfide removal, Sulfur recovery

1. Introduction

Wastewater containing sulfide is a growing concern in today's world for it is found in both dissolved and gaseous state in industrial waste and sewage. Wastewater contains dissolved sulfide whereas waste gases contain sulfide in gaseous hydrogen sulfide form [Dutta et al., 2008]. Sulfide is found in sewage and industrial effluents generated from petrochemical plants, tanneries, viscose rayon factories etc. [Cai et al., 2013].This sulfide in wastewater is a toxic, corrosive and malodourous pollutant [Zhang et al.,2011]. Sulfide removal is given utmost importance as it is harmful equally for health and environment. Besides presence of sulfide in sewage wastewater causes corrosion in the carrier pipes [Raschitor et al., 2015]and so reduces the pipe life eventually resulting in an economical loss. Hence sulfide removal along with recovery of it is important considering both economic and environmental points.

Removal of sulfide can be achieved in three different ways known as physical, chemical and biological processes. Biological process is the most budget friendly process considering its nominal demand for expensive chemicals and catalysts. Chemical process is efficient but involves use of expensive chemicals. And both these processes produce sludge which require further analysis. For this reasons electrochemical processes have been popular worldwide as they are superior over the other methods for having good energy efficiency, environmental compatibility, amenability to automation, versatility and cost effectiveness [Rajeswar et al., 1994]. Sulfide components (H_2S, HS^-,S^{2-}) are electrochemically very active which are able to react at anodic electrodes and donate electrons to the electrode. Experimental conditions control the fact whether elemental sulfur, polysulfide, sulfate, dithionate and thiosulfate are produced [Dutta et al., 2008]. Exploratory studies have found elemental sulfur to be the main product [Ateya et al., 2003] at potential difference higher than -0.273 V versus standard hydrogen electrode(SHE) [Rabaey et al., 2006]. Former studies have demonstrated sulfide removal in biological systems in presence of micro-organisms and residual organics [Dutta et al., 2008].

In this study a single chambered anaerobic digester was constructed which was fed with synthetic feed containing sulfide. Different potential varying from -0.3 to +0.3 was applied to the cell. After an electrochemical process had taken place elemental sulfur is formed which deposited on the anode and sulfate solution is left in the cell. Analysis of how much sulfate is formed finally gives the amount of sulfur produced on the anode.

2. Materials and Methods

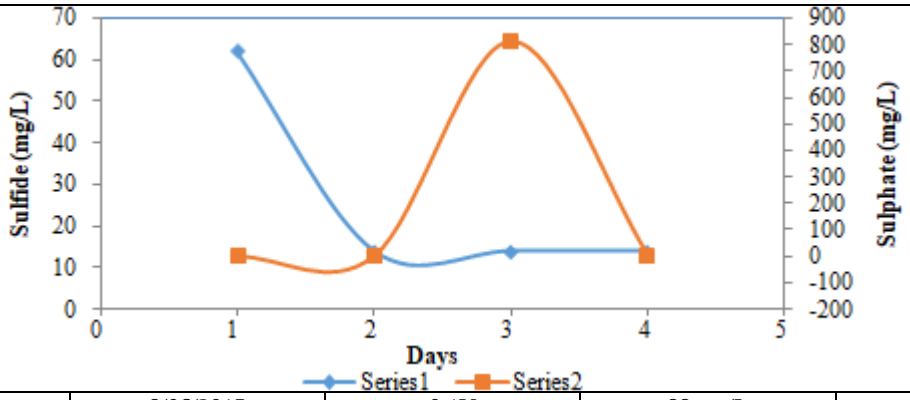
Cell Construction and Operation

Single chambered electrolysis cell was constructed using a 500 ml glass beaker. Total liquid volume of 450 ml was maintained during the operation. Graphite felt of actual surface area of 120 cm^2 was used.

The cell was fed with a saline buffer containing NaCl (1g L^{-1}), KH_2PO_4(5g L^{-1}),Na_2HPO_4(4g L^{-1}) and Nitrogen gas (N_2) was purged externally to maintain anaerobic condition. After that sulfide of 100 mg/L was added in each cell. Each cell set up was kept for 3 days and after every 24 hours readings for removed sulfide were noted down.

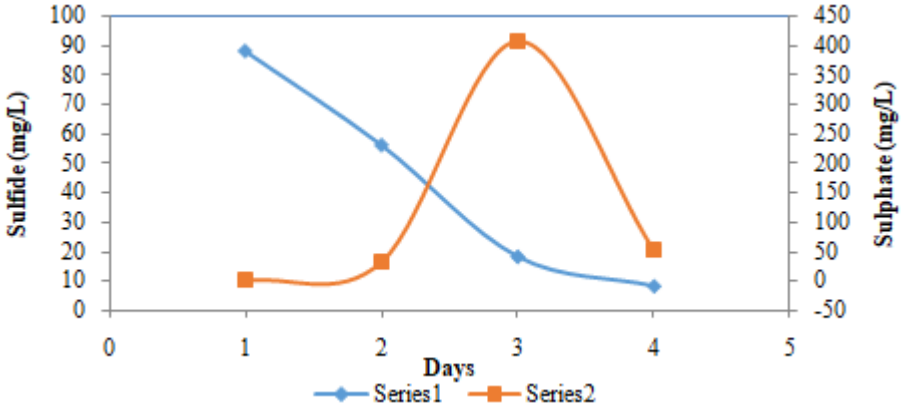
3. Results

Cycle	Date	Imposed Potential	S^{2-}	SO_4^{2-}
1.	23/05/2015	-0.5V	23.2 mg/L	0 mg/L
	24/05/2015	-0.5V	9.6 mg/L	21.4 mg/L
	25/05/2015	-0.5V	14 mg/L	37 mg/L
	26/05/2015	-0.5V	28 mg/L	18.6 mg/L
Removal Efficiency of Sulfide = No Removal				
2.	23/05/2015	0	23.2 mg/l	0 mg/L
	24/05/2015	0	26.67 mg/L	39.4 mg/L
	25/05/2015	0	28 mg/L	47.6 mg/L
	26/05/2015	0	34 mg/L	36.9 mg/L
Removal Efficiency of Sulfide = No Removal				
3.	26/05/2015	-0.1V	62 mg/L	0 mg/L
	27/05/2015	-0.1V	28 mg/L	0 mg/L
	28/05/2015	-0.1V	28 mg/L	122 mg/L
	29/05/2015	-0.1V	28 mg/L	40 mg/L
Removal Efficiency of Sulfide = 121.43%				
4.	26/05/2015	-0.2V	62 mg/L	0 mg/L
	27/05/2015	-0.2V	14 mg/L	0 mg/L
	28/05/2015	-0.2V	14 mg/L	816 mg/L
	29/05/2015	-0.2V	14 mg/L	0 mg/L
Removal Efficiency of Sulfide = 342.86%				



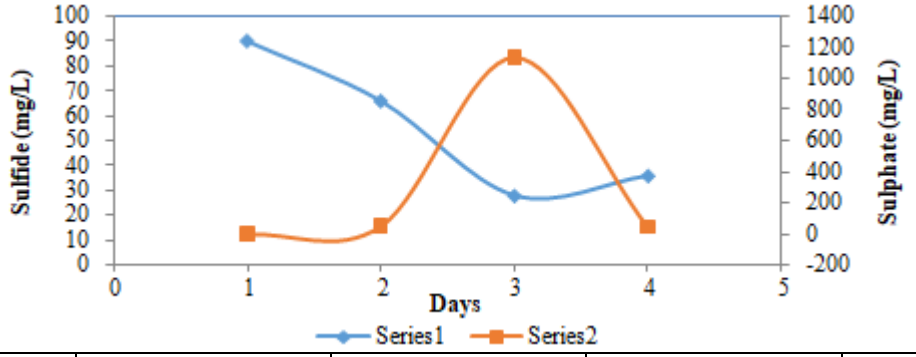
5.	8/06/2015	0.1V	88 mg/L	0 mg/L
	10/06/2015	0.1V	56 mg/L	32 mg/L
	11/06/2015	0.1V	18 mg/L	407.82 mg/L
	12/06/2015	0.1V	8 mg/L	51.75 mg/L

Removal Efficiency of Sulfide = 1000%



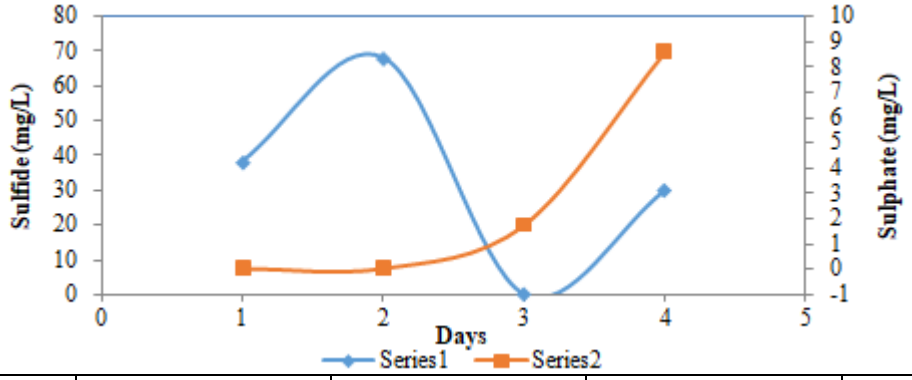
6.	8/06/2015	0.2V	90 mg/L	0 mg/L
	10/06/2015	0.2V	66 mg/L	52 mg/L
	11/06/2015	0.2V	28 mg/L	1141 mg/L
	12/06/2015	0.2V	36 mg/L	46.57 mg/L

Removal Efficiency of Sulphide = 150%



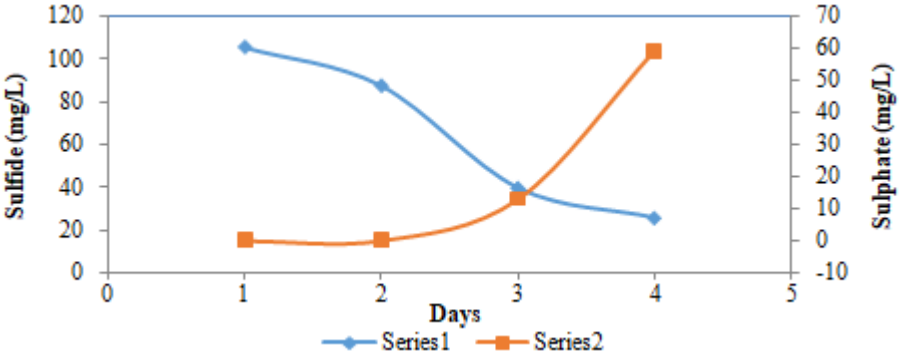
7.	16/06/2015	+0.3V	38 mg/L	0 mg/L
	17/06/2015	+0.3V	68 mg/L	0 mg/L
	18/06/2015	+0.3V	0 mg/L	1.73 mg/L
	19/06/2015	+0.3V	30 mg/L	8.6 mg/L

Removal Efficiency of Sulfide = 26.67%



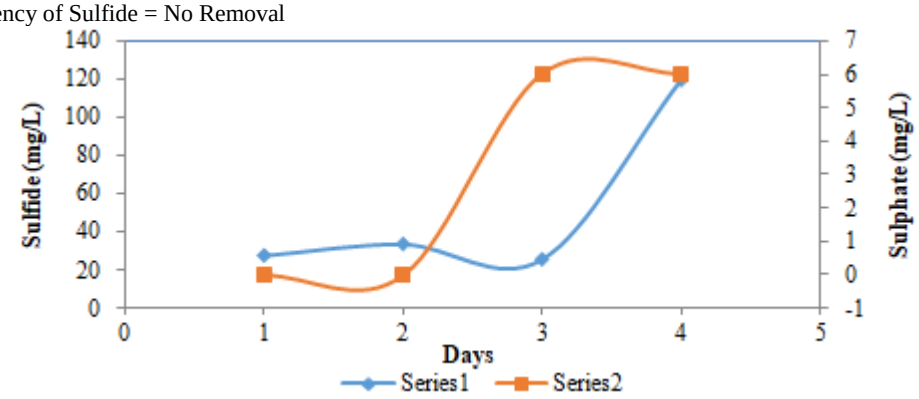
8.	16/06/2015	-0.3V	106 mg/L	0 mg/L
	17/06/2015	-0.3V	88 mg/L	0 mg/L
	18/06/2015	-0.3V	40 mg/L	13 mg/L
	19/06/2015	-0.3V	26 mg/L	59.5 mg/L

Removal Efficiency of Sulfide = 307.69%



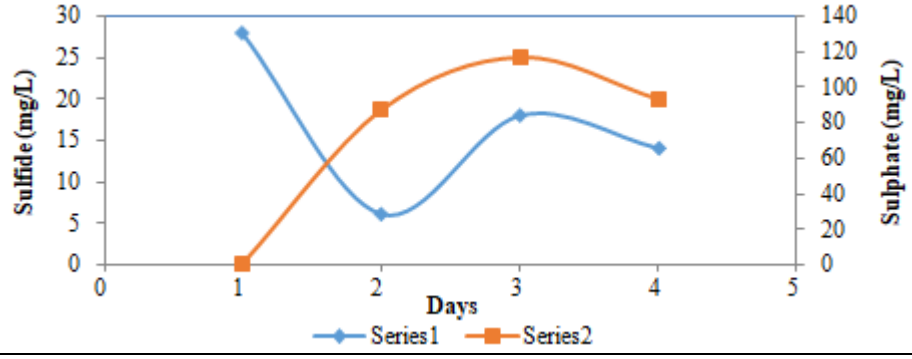
9.	23/06/2015	+0.2V	28 mg/L	0 mg/L
	24/06/2015	+0.2V	34 mg/L	0 mg/L
	25/06/2015	+0.2V	26 mg/L	6.04 mg/L
	26/06/2015	+0.2V	120 mg/L	6.04 mg/L

Removal Efficiency of Sulfide = No Removal



10.	23/06/2015	-0.2V	28 mg/L	0 mg/L
	24/06/2015	-0.2V	6 mg/L	87.1 mg/L
	25/06/2015	-0.2V	18 mg/L	117 mg/L
	26/06/2015	-0.2V	14 mg/L	93.1 mg/L

Removal Efficiency of Sulfide = 100%



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