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Effect of pH on sulfate removal from wastewater using a bioelectrochemical system

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HIGHLIGHTS

- Effective sulfate removal at pH 4.5 using a bioelectrochemical system is obtained.
- *Paludibacter* sp. might play an important role in sulfate removal at pH 4.5.
- The results can help to reduce the operation cost for acidic wastewater treatment.

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ABSTRACT

The effects of pH on sulfate pollutant removal, power generation and microbial community were investigated using a bioelectrochemical system, which was built on acclimatized sludge with sulfate at different pHs. For the experiment, ethanol was used as the electron donor for the reduction of sulfate pollutant. In the range of pHs between 2.5 and 10.5, the optimum condition for sulfate removal from wastewater is at pH 4.5 considering the capital cost, removal efficiency, chemical oxygen demand and coulombic efficiency. The results were different from previous studies that neutral condition is suitable for sulfate-reducing bacteria to treat pollutants. According to microbial community analysis, *Paludibacter* sp. might play the most important role in sulfate removal at pH 4.5. *Desulfuromonadaceae* sp., *Desulfobulbaceae* sp. and *Desulfovibrio* sp. were inferred to make major contributions to power generation. These results could help to reduce capital cost in treating acidic sulfate-rich wastewaters.

1. Introduction

Sulfate pollutants present commonly in wastewaters, which are produced in many processes such as mining, animal husbandry, food processing, pulp and paper wastewaters, dye and detergent manufacture [1]. Many of adverse effects have been generated, e.g. the wastewaters negatively affect the aquatic ecosystem; the reduced products volatilize into the atmosphere and contribute to acid rain; the generated toxic acidic gas raises serious health risks to living beings and is corrosive to materials [2]. To date, quite a lot of efforts have been made to treat the sulfate-rich wastewater. The techniques generally include precipitation [3], membrane separation [4] and biological methods [5,6]. At present, biological method is the most commonly used technique for sulfate-rich wastewater treatment because of the relatively low cost and energy consumption compared to physicochemical methods [7].

Bioelectrochemical system (BES), coupled electrochemical and biological treatment, has been considered as an effective method for sulfate removal. Habermann and Pommer set a microbial fuel cell for sulfate removal [8], even though the proposed mechanism still remains contentious; many efforts have been made to developing this field [9–12]. Compared with conventional biological techniques for sulfate-rich wastewater treatment, the BES has some outstanding advantages as follows: the generated toxic sulfide was used for the production of power and value-added elemental sulfur [13].

In the BES, sulfate-reducing bacteria play important roles in sulfate reduction and power generation. Sulfate is reduced to sulfide by employing sulfate-reducing bacteria, and then sulfide is oxidized to elemental sulfur deposited in the surface of electrode along with the power generation. Several species of sulfate-reducing bacteria, e.g. *Desulfovibrio desulfuricans* [11], *Desulfuromonas acetoxidans*, *Desulfobulbus propionicus* [14], had been confirmed to produce electricity with concomitant sulfate reduction. It has been reported that sulfate-reducing bacteria were generally suitable for growth in the neutral conditions of pH 6–8 and sensitive to pH changes [15]. In addition, the optimum pH for sulfate-reducing bacteria removing sulfate was neutral [16]. However, pH value of sulfate-rich wastewater largely derived from acidic wastewater is

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