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Swine wastewater treatment using a unique sequence of ion exchange membranes and bioelectrochemical system

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HIGHLIGHTS

- The flux via a cation exchange membrane played an important in ammonium removal.
- Electrochemical attraction enhanced ammonium transportation.
- Removal of organic matter and nitrogen was proportional to the applied voltage.

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ABSTRACT

An ion exchange biological reactor (IEBR) treated organic matter and nitrogen in swine wastewater at 23 °C. The enhanced IEBR enhanced the ammonium flux by electrochemical attraction. The abiotic ammonium fluxes at the applied voltage of 0, 1, and 3 V were 1.33, 1.79, and 2.73 mg/m^2/s, respectively. In the meantime, the ammonium fluxes caused by biological nitrification at the applied voltage of 0, 1, and 3 V were 1.54, 2.07, and 3.59 mg/m^2/s, respectively. Removal of organic matter and nitrogen in swine wastewater was proportional to the applied voltage. The average SCOD removal efficiencies at the applied voltage of 0, 1, and 2 V were 59.7%, 60.2%, and 67.0%, respectively. The average total nitrogen removal efficiencies at the applied voltage of 0, 1, and 2 V were 39.8%, 49.5%, and 58.7%, respectively.

1. Introduction

Since the husbandry industry intensively developed, a great amount of high-strength swine wastewater has been generated annually. USDA (2011) forecast that 10.5 million tons of pigs will be produced in the United States alone in 2012. The amount of swine and swine wastewater has been consistently increased due to the demand of red meat in developing countries. Most swine waste is produced by Asian countries. Asia is in the midst of tremendous increase for livestock. According to the Food and Agricultural Organization, swine produced in Asia was approximately 583 million head in 2010 (FAO, 2010). Asian countries such as China, India, and Korea posed the most significant impact to increasing the number of swine. Specifically, as of 2011, one half of pigs produced in the world are consumed in China (Chynoweth et al., 1999; FAO, 1996; USDA, 2011). Piggery waste is commonly comprised of high-strength organic matter, nutrient, and pathogenic organisms. Swine wastewater has to be treated to prevent surface/ground water contamination, odor, and pathogenic problems. Without an adequate treatment, it causes adverse impacts on human health and the ecosystems. In previous last decades, the land treatment of swine waste has been used for a good fertilizer or soil conditioner. However, it is necessary that high-strength organic waste in swine wastewater be properly treated before being discharged into a river or a land because untreated organic matter is detrimental to the environment and lowers the quality of fertilizer or soil conditioner (Luo et al., 2002; Schiffman et al., 2001; Sobsey et al., 2001).

Various processes were developed to treat swine manure. Often, anaerobic digestion has been used to treat swine wastewater because the concentrations of organic matter and nutrient in the influent are extremely high. Anaerobic processes to treat swine wastewater are exemplified by a continuous stirred tank reactor, an upflow anaerobic sludge bed reactor, an anaerobic sequencing batch reactor, an anaerobic baffled reactor, and a static granular bed reactor (Chynoweth et al., 1999; Lim and Fox, 2011; Lo et al., 1994; Yang and Chou, 1985). Since the 1990s, bioelectrochemical systems (BES) have been one alternative to treat various wastewaters. The greatest advantage of using BES is an electrical transfer of

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