ABSTRACT

Use of inedible starchy food grains is rather considered as preferred substrate, yielding higher percentage of ethanol and generating wastewater called thin stillage. Grain thin stillage is comprised of high chemical oxygen demand (COD) as 40 – 60 g/l, high total suspended solids (TSS) as 25 – 30 g/l and acidic pH of 3.4 – 4.1. Conventionally practised wastewater treatment includes sequential anaerobic-aerobic processes, concentration or evaporation and incineration; however, these are unable to offer a sustainable treatment solution to achieve wastewater inland disposal norms for distillery wastewater. Researchers have explored advanced treatment processes; however, most of the case studies were reported in lab-scale.

A systematic effort has been made in this research to establish a two-stage novel, effective and advantageous process involving biodegradation of thin stillage by filamentous fungi *Aspergillus awamori*, which is followed by further treatment of effluent in microbial fuel cell (MFC). Development of statistical and bio-kinetic model equations for fungal biodegradation of thin stillage and recovery of bio-polymer chitosan as by-product was intended to add value to the developed process. It was also aimed to enhance power generation in MFC by suppressing methanogenic *Archaea* with low-cost tricho-toxin peptaibiotics, derived from *Trichoderma* sp.

Statistical model equations were derived by using full factorial design, where fungal growth parameters were optimized for biodegradation of thin stillage as air flow rate of 1200 ml/min, fungal incubation time in the range of 108 - 120 h and initial total solids concentration in substrate thin stillage as 14.8 g/l, which were found to be the most significant fungal growth-limiting factors and response curves were expressed as 95% confidence interval. Fungal biodegradation kinetics and mass balance equations were successfully derived and extraction of chitosan from the cell wall of fungal mycelia cultivated in thin stillage wastewater was also demonstrated. Combined fungal biodegradation-MFC treatment attained around 99% of organic removal efficiency, to produce treated wastewater with 80 to 100 mg/l of Biochemical oxygen demand (BOD), meeting the inland disposal standards for irrigation. Almost complete inhibition of *Archaea* was achieved in inoculum of MFC when treated with Neoatroviridin (A-D), demonstrating 9.68 W/m^3 of power density (PD) with 53.5% coulombic efficiency (CE) and 12.5 W/m^3 of PD with 21% of CE, while using non-fermentable acetate wastewater and fermentable fungal pre-treated distillery wastewater as substrate, respectively, in MFC. It is also estimated that the net equivalent power, generated by employing MFC for further treatment of fungal pre-treated wastewater, is 1.4 times higher as compared to the power that can be obtained from electricity derived from the generated methane in bio-methanation process while treating raw distillery wastewater.

Keywords: Chitosan recovery; Distillery wastewater treatment; Fungal biodegradation; Methanogenic suppression; Microbial fuel cell; Peptaibiotics; Statistical optimization; Two-stage process