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Aerobic and Anaerobic Waste Water Treatments as Microbial Fuel

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Abstract: Anaerobic wastewater treatment differs from conventional aerobic treatment. The absence of oxygen leads to controlled conversion of complex organic pollutions, mainly to carbon dioxide and methane. Anaerobic treatment has favourable effects like the removal of higher organic loading, low sludge production, high pathogen removal, biogas gas production and low energy consumption. Psychrophilic anaerobic treatment can be an attractive option to conventional anaerobic digestion for municipal sewage and industrial wastewaters that are discharged at moderate to low temperature. Keywords anaerobic biodegradation, anaerobic processes, anaerobic wastewater treatment, energy recovery.

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INTRODUCTION

Aerobic treatment systems such as the conventional activated sludge (CAS) process are widely adopted for treating low strength wastewater (< 1000 mg COD/L) like municipal wastewater. CAS process is energy intensive due to the high aeration requirement and it also produces a large quantity of sludge (about 0, 4g dry weight/g COD removed) that has to be treated and disposed of.

As a result, the operation and maintenance cost of a CAS system is considerably high. Anaerobic process for domestic wastewater treatment is an alternative that is potentially more cost-effective, particularly in the sub-tropical and tropical regions where the climate is warm consistently throughout the year.

Anaerobic digestion consists of several interdependent, complex sequential and parallel biological reactions, during which the products from one group of microorganisms serve as the substrates for the next, resulting in the transformation of organic matter mainly into a mixture of methane and carbon dioxide. Anaerobic digestion takes place in four phases: hydrolysis/liquefaction, acidogenesis, acetogenesis, and methanogenesis. To ensure a balanced digestion process it is important that the various biological conversion processes remain sufficiently coupled during the process so as to avoid the accumulation of any intermediates in the system. Microorganisms from two biological kingdoms, the Bacteria, and the Archaea, carry out the biochemical process under strict anaerobic conditions (Parawira, 2004).

PURPOSE OF THE RESEARCH

The purpose of this research was to develop and test an anaerobic microbial fuel cell (MFC) at pilot-scale. In laboratory-scale research, MFCs have been shown to simultaneously treat organic wastewater and generate electricity. However, most MFC studies have been limited to small (typically <250 mL) batch reactors using a single compound or simulated wastewater. This project operated 16 liters (L) reactor in a continuous flow using filtered municipal primary effluent as the feedstock.

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Potential Applications of the Research

Anaerobic MFCs use substantially less energy to treat wastewater than conventional aeration technologies. It is estimated that wastewater treatment uses approximately 3% of the electrical power consumed nationwide (Logan, 2005). By generating renewable electricity on-site, MFCs could help enable municipal wastewater treatment plants to become self-sustaining. Additionally, the extension of MAC-GACMFC technology to higher strength wastewaters, such as those generated in the food, beverage and dairy industries, have obvious application as sustainable, renewable energy production alternatives.

Psychrophilic Anaerobic Treatment Process

Although anaerobic wastewater treatment plants for municipal wastewater have been successfully operated in tropical countries such as Mexico, Columbia, India, and China, the process until now has not been applied in countries with moderate and low temperatures. At such temperatures, chemical oxygen demand (COD) removal is limited and long hydraulic retention time is needed for one step system to provide sufficient hydrolysis of particulate organics (Gasparikova, 2005). Low temperature causes a deleterious effect on anaerobic digestion because of the relatively longer generation time of anaerobic bacterial populations and lower biochemical activity, resulting in the decrease of biogas yield and digester failure (Singh et. al., 1999). The start-up and treatment of municipal wastewater in cold regions were investigated in two UASB reactors operated at temperatures of 32, 20, 15, 11, and 6° C with several HRTs ranging from 48 to 3 h (Singh and Viraraghavan, 1999). Biomass aggregation (granulation) was achieved in approximately 281 d at 20° C.

Biodegrading of Persistent Organic Compounds

Under psychrophilic conditions, chemical and biological reactions proceed much slower than under mesophilic conditions. Most reactions in the biodegradation of organic matter require more energy to proceed at low temperatures than at a temperature optimum of 37°C (mesophilic conditions) (Table 1). However, some reactions, such as hydrogenotrophic sulfate reduction, hydrogenotrophic methane production and acetate formation from hydrogen and bicarbonate, require less energy.A strong temperature effect on the maximum substrate utilization rates of microorganisms has been observed by many researchers. In general, lowering the operational temperature leads to a decrease in the maximum specific growth and substrate utilization rates but it might also lead to an increased net biomass yield (g biomass g^{-1} substrate converted) of the methanogenic population or acidogenic sludge (Lettinga et. al, 2001). Table 1. Stoichiometry and Gibbs free-energy changes of acetate, propionate, butyrate and hydrogen anaerobic conversion in the presence and absence of sulphate (Lettinga et. al, 2001).

Effect of Low Temperature on the Physical and Chemical Properties of Wastewater

A drop in temperature is accompanied by a change of the physical and chemical properties of the wastewater, which can considerably affect design and operation of the treatment system. For instance, the solubility of gaseous compounds increases as the temperature decreases below 20°C. This implies that the dissolved concentrations of methane, hydrogen sulfide, and hydrogen will be higher in the effluent of reactors operated at low temperatures than those from reactors operated at high temperatures. The high increase in solubility of CO2 indicates that a slightly lower reactor pH might prevail under psychrophilic conditions

pH and Conductivity

An Orion Three Star pH meter and conductivity meter (Thermo Scientific Beverly MA) were used, following standard procedures. The pH meter was calibrated with pH 4 and 10 standard buffers and checked with a pH 7.0 standard before field measurements. The conductivity meter was checked with 12.9 and1.314 mS/cm standards before field measurements.
Domestic West water characteristics:

The man reason for designing of sewage treatment plant or building sewer in the cities is domestic waste water.
The waste water characteristic is divided into two part:

1. Physical characteristic
2. Chemical or industrial characteristic.

CHEMICAL CHARACTERISTICS

During the chemical waste, water characteristic is more complicated than explaining the attributes of the physical. There are a lot of different chemical element in waste water which makes the exact chemical measurement impossible. However the experts in the field divided the wastewater chemicals into generals groups of the compound for making the measurements easier; for example polyphosphates, orthophosphates and organic phosphate are all being considered under a major group called "Total Phosphorus (as P). Mono-hydrogen phosphate (HPO4 2-) is usually determined to be phosphorus in waste water. Its existence in order to prevent the reduction of eutrophication and this process put to use through chemical precipitation, using the three compound method given below:

USING FERIC CHIORIDE:

Fecl3 + (HPO4)2-= FePO4 + H+ +3CL-

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USING ALUM :

$$Al_2(SO_4)_3 + 2(HPO_4)^{2-} = 2AlPO_4 + 2H^+ + 3(SO_4)^{2-}$$

USING LIME:

$$5Ca(OH)_2 + 3(HPO_4)^{2-} = Ca_5(PO_4)_3OH + 3H_2O + 6(OH)^-$$

The ph value of domestic waste water is estimated

between 6.5 to 8.5.

SUMMARY

The feasibility of high-rate anaerobic wastewater treatment (AnWT) systems for cold wastewater depends primarily on: (1) the quality of the seed material used and its development under sub- mesophilic conditions; (2) an extremely high sludge retention time under high hydraulic loading conditions because little if any viable biomass can be allowed to wash out from the reactor; (3) an excellent contact between retained sludge and wastewater to utilize all the available capacity within the bioreactor; (4) the types of the organic pollutants in the wastewater; and (5) the reactor configuration, especially its capacity to retain viable sludge.

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