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HYDROLYSIS AND ACIDOGENESIS OF PARTICULATE ORGANIC MATERIAL IN MESOPHILIC AND THERMOPHILIC ANAEROBIC DIGESTION

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ABSTRACT

The purpose of this study was to evaluate the effect of pH and inorganic nutrient supplementations for anaerobic hydrolysis and acidogenesis of particulate organic materials at both mesophilic (35 °C) and thermophilic (55 °C) temperatures. Hydrolysis and acidogenesis of a synthetic sludge was observed in batch operation for the evaluation of the pH effect. pH was uncontrolled in one reactor and controlled at 4.5, 5.5, and 6.5 in the other three reactors at both temperatures. The greatest degree of hydrolysis and acidogenesis occurred when the pH was controlled at 6.5. The pH of the uncontrolled reactor dropped to 3.4 at both temperatures severely retarding hydrolysis and acidogenesis. Concentrations of acetic and n-butyric acids predominated with lower concentrations of propionic acid at both temperatures in all reactors. Lactic acid was produced as the earliest intermediate but as the reaction proceeded, short chain VFAs were produced as final end products with a decrease in lactic acid. The higher the pH, the earlier this trend was observed. For the controlled reactors at pH 6.5, the soluble COD production and the VSS reduction peaked in 4 days at 55 °C whereas it took about 11 days at 35 °C to obtain the same result. During the linear SCOD production period at a pH of 6.5 the hydrolysis rate of the thermophilic reactor was greater than that for mesophilic. Thermophilic conditions appeared to be more sensitive to pH than mesophilic ones for both hydrolysis and acidogenesis. Additional experiments were conducted to establish the effect of inorganic nutrient (Ca, Fe, Co, and Ni) supplementation on hydrolysis and acidogenesis at both temperatures. It has, prior to this, been assumed that only methanogenesis benefited from trace metal supplementation. However, the results demonstrated the importance of inorganic nutrient supplementation to optimize hydrolysis and acidogenesis at both temperatures.

Keywords: Acidogenesis, hydrolysis, inorganic nutrient supplementations, mesophilic, pH, thermophilic

INTRODUCTION

The primary objective of anaerobic digestion of wastewater sludges is to stabilize organic matter with a concurrent reduction in odors, pathogen concentration, and the volume of solid organic material still requiring further processing as well as to produce a corresponding amount of biogas [1,2]. In general bacteria are unable to take up particulate organic material because a breakdown into soluble polymers or monomers is required first [3]. Hydrolysis of insoluble organics is necessary to convert these materials to a size and form that can pass through bacterial cell walls for use as energy or nutrient sources. Once complex organics are hydrolyzed, they can be fermented into long-chain organic acids, sugars, and amino acids, and eventually into smaller organic acids such as propionic-, butyric-, and valeric-acid. Acetic acid, hydrogen, and carbon dioxide are also formed during the production of organic acids. Waste stabilization occurs during the methanogenic phase by conversion of the acetic acid and hydrogen into methane, which is essentially insoluble in water and readily separates from the sludge in the gas which leaves the system [1,3].

In order to increase the stability of anaerobic digestion the two-phase anaerobic system has been introduced and investigated [4-6]. The physical separation of hydrolysis/acidogenesis and methanogenesis steps increases process stability because methane reactor overload can be prevented by proper control of the first step [5]. Advantages of phase separation include increased stability with better control of the acid phase, higher organic loading rates, increased specific activity of methanogens leading to an increase in methane production rates, removal of compounds toxic to methane bacteria, provision of a constant substrate for the methanogens. However, possible disadvantages of phase