

Microbial composition assessment of anaerobic biomass through methanogenic activity tests

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Abstract

Maintenance of sufficient methanogenic populations is critical for stable performance of anaerobic systems. The usually monitored parameters like COD removal, VFA levels, quantity and composition of biogas produced etc., do not reflect the composition of biomass under varied operational/environmental conditions. The change in biomass composition in terms of relative population levels of methanogens has been indirectly assessed through methanogenic activity tests using two different substrates at equivalent COD load. The results of activity tests have been well correlated with the performance results of the bench-scale upflow anaerobic filter. This clearly suggests the use of the methanogenic activity test to monitor biomass composition along with usually monitored parameters for obtaining a better insight into the reactor stability and performance.

Abbreviations

AMA	acetoclastic methanogenic activity
AMGPR	average methane gas production rate
BA	bicarbonate alkalinity
EBHRT	empty bed hydraulic retention time
F	final
I	initial
HOM	hydrogen oxidising methanogens
NHOM	non-hydrogen oxidising methanogens
OLR	organic loading rate
SMA	specific methanogenic activity
TMA	total methanogenic activity
UAF	upflow anaerobic filter
VFA	volatile fatty acids
VSS	volatile suspended solids

Introduction

Several anaerobic process variants having specific biomass retention mechanisms are available for field application. Laboratory-, pilot- and full-scale studies have made varied claims regarding applicability and performance of these process variants (Henze and Harremoës, 1983; Stronach et al., 1986; Hickey and Goodwin, 1989; 1991; Lettinga et al., 1980; Pol and Lettinga, 1986). Maintenance of sufficient methanogenic populations in the system is critical for stable performance. Methanogenic species types and their relative population levels in reactor biomass depend on wastewater characteristics as well as operational/environmental conditions maintained (Novaes, 1986). Any imposed stress (intentional or otherwise) may lead to a change in species types and their relative population levels which is ultimately reflected in the reactor performance (Harper and Pohland, 1986). The reactor performance is usually evaluated in terms of process efficiency and

stability through estimation of organic matter removal, VFA levels, quantity and composition of biogas produced, etc. However, little effort has been made to assess reactor biomass in terms of relative population levels of methanogenic species under varied operational/environmental conditions.

Counts of methanogens and non-methanogens in reactor biomass have been made by several investigators (Kotze et al., 1969; Hobson and Shaw, 1974; Zeikus, 1980; Gregori et al., 1979; Novaes et al., 1984; Agrawal et al., 1997). These efforts led to the development of well-established laboratory techniques (Ranade and Gadre, 1988). However, these techniques require a high level of skill, advanced equipment, and costly and specific growth media which restrict its application at the plant site. SMA tests on anaerobic sludges (biomass) have been gaining importance. Initially, these tests were mainly used to select an adapted sludge as inoculum (James et al., 1990) but now these tests can also be used for many other purposes such as to:

- Evaluate the behaviour of sludge under the effect of potentially inhibitory compounds (Harada et al., 1994; Perle et al., 1995)
- Establish the degree of degradability of various substances (Stewart et al., 1995)
- Follow the changes in sludge activities due to a possible build-up of inert materials
- Estimate maximum applicable loading rate to a certain sludge (Ince et al., 1995)
- Evaluate batch kinetic parameters, etc.

A number of methods have been proposed for the estimation of maximum methanogenic activity. The summary of experimental conditions is presented in Table 1. Some of these methods are quite simple (Valcke and Verstraete, 1983; De Jong, 1986; Field et al., 1988; Soto et al., 1993) but the sample volume needed is too high (500 mL or larger). Several solutions were proposed to reduce the working volume and to automate the monitoring process (Owen et al., 1979; Shelton and Tiedje, 1984; Dolfing, 1985; Bonastre et al., 1987; Concannon et al., 1988; James et al., 1990; Grotenhuis et al., 1991; Rintala and Lepistö, 1992; Soto et al., 1993). Very small working volumes (30 to 125 mL) lead to smaller amounts of

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