ABSTRACT

Based on previous laboratory studies, the anaerobic baffled reactor (ABR) has been suggested as a waterborne, on-site sanitation option for low-income, peri-urban settlements. This study was part of a larger project, which set out to investigate the performance of a pilot-scale ABR (3 000 L) treating domestic wastewater. For this study, emphasis was placed on the pathogen indicator removal and the microbial population dynamics of the reactor. The reactor was operated at two flow regimes, a hydraulic retention time (HRT) of 22 h (case study 1) and one of between 40-44 h (case study 2), and the various aspects of performance evaluated.

At an average HRT of 22 h, an average chemical oxygen demand (COD) removal efficiency of 72% was achieved, which complied with effluent discharge regulations for agricultural irrigation. Nutrient concentrations remained relatively unaffected by anaerobic digestion. The high level of plant nutrients in the effluent suggests its potential application as a fertiliser. The major re-use concern, however, was the high pathogen indicator counts. Although statistically significant removal efficiencies of *Escherichia coli* (*E. coli*) and total coliforms were observed, a further 3-$\log_{10}$ reduction would be required to produce an effluent which conformed to discharge standards. It was hypothesised that the ABR was capable of improved performance, as several technical difficulties, associated with control and supply apparatus, might have affected the performance of the reactor.

Consequently, the ABR was operated at an average HRT of 40-44 h. Whilst nutrient concentrations remained relatively unaffected, COD removal efficiency increased to 82%, and was again well below agricultural re-use guidelines. There were also improvements in the removal efficiencies of *E. coli* (from 68% to 76%), total coliforms (from 61% to 83%), and total suspended solids (TSS) (from 50% to 68%). It was hypothesised that the improved indicator removal at a HRT of 40-44 h may be due enhanced solids retention and improved reactor stability. Statistically significant reductions of coliphage and *Ascaris* eggs (≥ 94%) were also achieved at a HRT of 40–44 h. However, the pathogen indicator counts in the effluent were still above recommended discharge levels. A small-scale trial, using a microfiltration membrane, was investigated as possible post-treatment option. The limited results indicated that an effluent of appropriate discharge quality could be produced using a microfiltration membrane.

With respect to the microbial population dynamics of the ABR, the hypothesis of the horizontal separation of acidogenic and methanogenic consortia through the ABR was not substantiated by scanning electron microscopy (SEM) observations at a HRT of 22 h. This was thought to be due to the slow rate of hydrolysis of particulate organics within the wastewater. This resulted in scavenging of volatile fatty acids (VFA) by microorganisms resembling methanogens, especially those resembling hydrogenotrophic methanogens (*Methanospirillum*-like microorganisms, *Methanococcus*-like microorganisms, and *Methanobrevibacter*-like microorganisms) in the first few compartments of the reactor. Contrary to literature, microorganisms resembling *Methanosaeta* species were rarely observed. It is suggested that under conditions of 'stress' (high flow and 'washout', low pH), there was a selection for *Methanosarcina*, possibly due to its faster growth and greater tolerance to 'adverse' environmental conditions over *Methanosaeta*.

The results were in marked contrast to the study conducted at an average HRT of 40-44 h, where a partial separation of acidogenic and methanogenic phases was observed. However, this separation was different in form to those described in literature, as methanogenesis occurred predominantly near the front of the reactor. Scavenging by microorganisms resembling hydrogenotrophic methanogens occurred at the front of the reactor. There were also comparatively larger populations of acidogenic and acetogenic bacteria observed at this flow regime. In addition, there were changes in the distribution of microorganisms resembling acetoclastic genera. A few *Methanosarcina*-like populations were observed in compartment 1, whilst larger *Methanosaeta*-like populations were found in subsequent compartments. The latter was found to predominate in compartments 2 and 3, mostly in the form of granular sludge. Although the phenomenon of granulation was observed at both flow rates, they were poorly developed and did not have any significant microbial populations on the surface or within the core when the HRT was 22 h. However, observations made at a HRT of 40-44 h, showed the presence of two-layered granules, consisting of a mixed population on the outer surface and a large central core composed primarily of microorganisms resembling *Methanosaeta* species. The results suggested that *Methanosaeta* was a key-role player in the development of granules, in keeping with other theories of granulation. An additional observation of microorganisms resembling acidogenic bacteria around extracellular polymer (ECP)-bound aggregates of *Methanosaeta*-like cells within the granule core, led to the development of a proposed model of granule biogenesis, which differed from those described to date. These results clearly indicated that the HRT had a major influence on the microbial population dynamics of an ABR treating domestic wastewater.