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Physicochemical properties and trace organic compounds in a dairy processor's aerobic bioreactor

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HIGHLIGHTS

- Dairy processing wastewater is analysed for indicators of bioreactor performance.
- Physicochemical and GC–MS analyses are combined using metabolomic techniques.
- Phosphorus concentrations is related to bioreactor mixed liquor.
- Nitrogen concentrations are related to infeed into mixed liquor.
- 4-Nitrophenol is correlated to analyses relating to anaerobicity (e.g. NH_3/NO_3).

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ABSTRACT

Wastewater samples were taken from an aerobic bioreactor, operated by a dairy processor in southeastern Australia to reduce nutrient and pollutant loads. Samples were taken over a two-year period, to determine whether trace organic compounds or physicochemical analyses of the wastewater could be used to discriminate the water taken before, during and after processing of the wastewater in the bioreactor. Multivariate analyses of the physicochemical data suggested that nitrate, pH and total dissolved nitrogen best described the infeed wastewater entering the bioreactor, while organic and particulate phosphorus concentrations where predominantly responsible for describing the composition of the content of the bioreactor. Gas chromatography–mass spectrometry data of organic compounds within the wastewater samples were also analysed via multivariate analyses. The analyses found that the compound 4-nitrophenol was associated with ammonia concentrations and mixed liquor wastewater. Therefore, 4-nitrophenol may possibly be used to act as an indicator of anaerobicity in aerobic bioreactors.

1. Introduction

In Australia, dairy processing facilities annually consume on average 386 ML of potable water and produce 452 ML wastewater (Allinson and Dyer, 2007). Wastewater from dairy processors can be some of the most polluted in the food industry with up to 10 L of wastewater produced per litre of processed milk (Vourch et al., 2008). Consequently it is common for dairy processors to segregate and treat wastewater prior to disposal or reuse (Wilkinson et al., 2007). The wastewaters generally contain residual milk and milk derivatives (e.g. casein, whey), along with cleaning and buffering agents used within the processing plant. Milk residues consist of proteins, carbohydrates and fats, which account for a large proportion of the chemical oxygen demand (COD) in dairy factory wastewaters (Demirel et al., 2005). For example, milk fats (35–500 mg/L) and proteins (210–560 mg/L) were detected in dairy effluent wastewaters when investigating typical digestion problems in anaerobic digesters (Perle et al., 1995). Without prior treatment, these compounds can adversely affect municipal waste treatment systems receiving dairy processing wastewaters.

Operating an aerobic bioreactors is one method of pre-treating dairy processing waste and lessening COD, total phosphorus (TP) and total nitrogen (TN) concentrations. Compared to anaerobic bioreactors, aerobic bioreactors provide for more complete degradation of the effluent found in dairy factory waste (Chan et al., 2009). However, compounds in dairy processing wastewaters vary over time in both composition and concentration and it is not uncommon for the load on the bioreactor to double compared to

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