Chapter 6
Autotrophic Denitrification Processes

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ABSTRACT

Effluents coming from anaerobic digesters are characterized by a COD/N ratio between 2 and 10, high ammonia NH_4^+ concentrations about 500 mg/L and a temperature range of 25-35 ºC. To remove nitrogen from these effluents biological processes as the autotrophic denitrification with sulfur compounds, hydrogen or methane can be applied. The main goal of this chapter is to describe and evaluate the use of these processes from an economic point of view. The methanotrophic denitrification is the cheapest alternative to remove nitrate from effluents with low COD/N ratios.

INTRODUCTION

Anaerobic digestion is the process most utilized for organic matter removal in industrial wastewater with high Chemical Organic Demand/Nitrogen (COD/N) ratio (> 10 g/g), such as coming from marine products industries, livestock industry, agri-food industry, aquaculture, among others.

This process achieves relative high removal efficiency (> 80%) of carbonaceous compounds of wastewater but has a low efficiency (< 20%) regarding the nitrogen removal.

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Effluents coming from anaerobic digesters are characterized by a COD/N ratio between 2 and 10 g/g, high ammonium (NH_4^+) concentrations (about 500 mg/L) and a temperature range of 25-35 ºC. To remove nitrogen from these effluents, the biological processes based on the biogeochemical nitrogen cycle are the most commonly using. However, the application of this process depends on the COD/N ratio that is present in the wastewater (Campos *et al.*, 2010).

When the COD/N ratio of the wastewater is higher than 5, the combination of conventional nitrification (sequential NH_4^+ oxidation to nitrite (NO_2^-) and nitrate (NO_3^-)) and heterotrophic denitrification (nitrate or nitrite reduction to nitrogen gas (N_2)) processes are the most used as treatment (Ahn, 2006). While the COD/N ratio of the wastewater is lower than 5, the addition of an external carbon source is necessary to remove nitrogen by heterotrophic denitrification, being more expensive the treatment. Autotrophic denitrification is considered an advanced process to remove nitrogen in effluents with low COD/N ratio (Ahn, 2006) (Figure 1). This process is characterized by using inorganic compounds such as sulfur compounds, hydrogen (H_2) or methane (CH_4) (Equations 1, 2 and 3) as electron donors to remove nitrogen and inorganic carbon as a carbon source. Therefore, autotrophic denitrification could be an attractive and suitable alternative for the treatment of wastewater with low COD/N ratios as effluents coming from anaerobic digesters, in comparison with the heterotrophic denitrification.

$$5S^0 + 6NO_3^- + 2H_2O \rightarrow 3N_2 + 5SO_4^{2-} + 4H^+ \tag{1}$$

$$5H_2 + 2NO_3^- \rightarrow N_2 + 4H_2O + 2OH^- \tag{2}$$

$$5CH_4 + 8NO_3^- + 8H^+ \rightarrow 4N_2 + 5CO_2 + 14H_2O \tag{3}$$

Figure 1. Partial cycle of nitrogen: nitrification and denitrification