Distillery Wastes as External Carbon Sources for Denitrification in Municipal Wastewater Treatment Plants

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The efficiency of denitrification in biological nutrient removal (BNR) wastewater treatment plants (WWTPs) is strongly dependent on the availability of appropriate carbon sources. In order to enhance the process within the existing capacities, the simplest solution is to add external carbon sources to anoxic compartments. There is a number of effective, commercially available and organic compounds (such as methanol, ethanol, acetic acid, sodium acetate and glucose) which can be categorized as the "conventional" carbon sources. Primarily due to high costs of those compounds, various industrial by-products or waste materials have recently received more attention as the "alternative" external carbon sources, but their full-scale applications have been less documented. Recently, Gu and Onnis-Hayden (2010) presented a comprehensive literature review that summarized various types of external carbon sources that can be applied for enhancing denitrification.

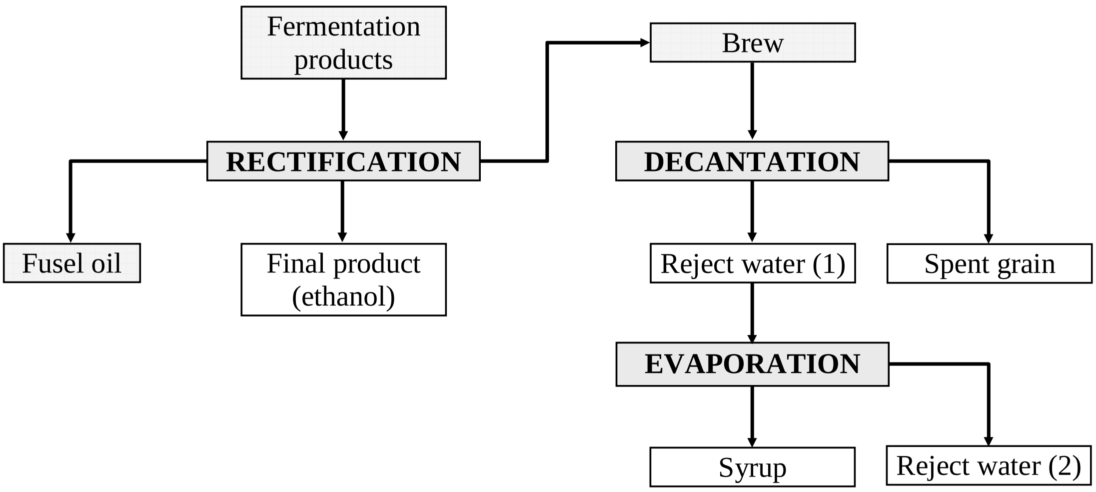

Figure 1 Diagram showing waste products in the process of alcohol production.

Table 1 Characteristics of the waste products in the process of alcohol production.

Parameter	Unit	Fusel oil	Reject water (1)	Syrup
COD (total)	g COD/m^3	1,690,000	80,000	399,000
COD (filtered sample)	g COD/m^3	1,690,000	46,000	234,00
TN	g N/m^3	960	156	586
NH_4-N	g N/m^3	2.5	88	213
NO_3-N	g N/m^3	77	18	126

In Poland, the alcohol production industry provides a great potential for the "alternative" carbon sources to be applied in medium and large WWTPs facing with the stringent EU effluent regulations (TN = 10-15 g N/m^3). Ethanol produced in approximately 900 agricultural and 6 industrial distilleries and the total annual production for industry and consumption is over 250 million dm^3. During the production process, a few waste products are generated including fusel oil, reject water and syrup (Figure 1). Their basic characteristics are listed in Table 1. Fusel oil and reject water (1) are generated in the amount of 0.5 and 1000%, respectively, with respect to the ethanol produced. Fusel oil was already identified as an interesting “alternative” carbon source as the observed nitrate utilization rates (NURs) with the support of fusel oil were higher in comparison with ethanol and methanol (Makinia et al., 2011). In this paper, other distillery waste products (reject water (1) and syrup) were evaluated with respect to their potential for enhancing denitrification and interactions with enhanced biological P removal (EBPR) in BNR WWTPs.

Three kinds of batch experiments, including the “conventional” denitrification, denitrification preceded by an anaerobic phase and oxygen uptake rate (OUR) measurements, were carried out with samples of the waste products from a local medium-size distillery and non-acclimated process biomass from a BNR wastewater treatment plant in Gdansk (570,000 PE). For comparison, other carbon sources, such as settled wastewater, ethanol and acetic acid, were also used in similar experiments in a parallel batch reactor. During the experiments, samples of the mixed liquor were frequently analyzed for NO_3-N, NO_2-N, PO_4-P and COD.

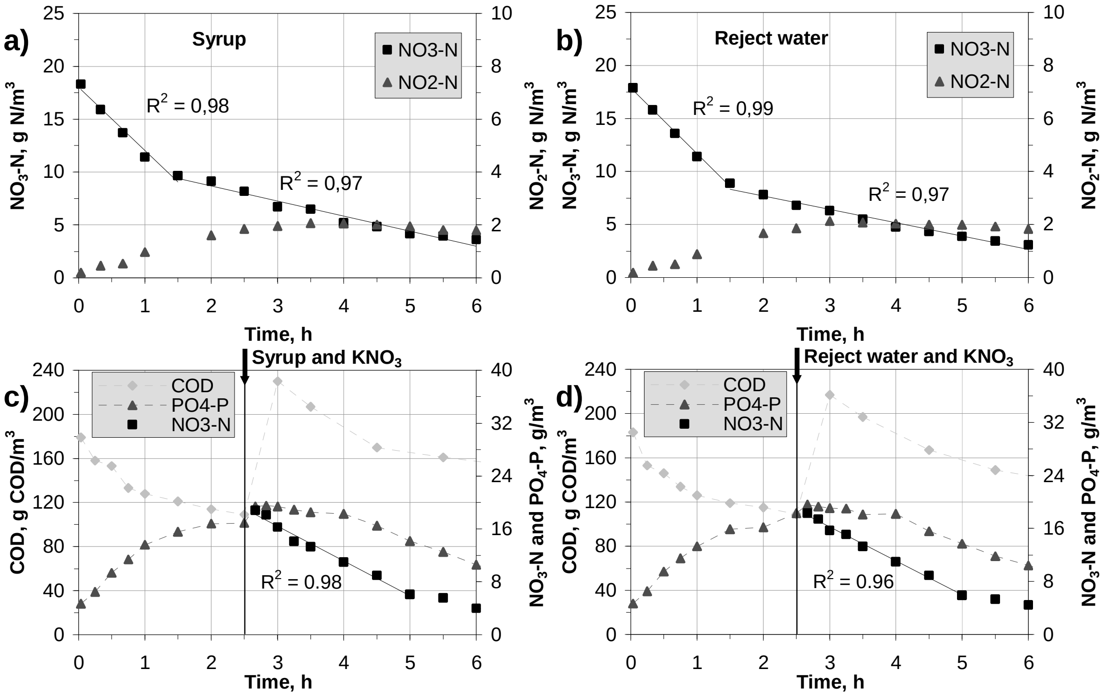

Figure 2 Sample results of the NUR measurements with syrup and reject water (1) in the batch reactors.

Sample results of the NUR measurements are presented in Figure 2. The observed rates (NUR1 = 3.7-3.8 g N/(kg VSS·h)) in the first phase of the “conventional” denitrification tests were lower compared to the readily biodegradable fraction of the settled wastewater (4.8-5.6 g N/(kg VSS·h)). When adding the waste products at the beginning of the anoxic phase preceded by an anaerobic phase (two-phase experiments), the range of observed NURs, i.e. 5.1-5.3 g N/(kg VSS·h), was significantly higher to the reference tests without addition of external carbon sources (2.4-2.8 g N/(kg VSS·h)). The anoxic P uptake rates (PURs) (2.0-2.1 g P/(kg VSS·h)) did not appear to be affected by the addition of the distillery waste products.

References

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