Innovative carbon source for enhancing denitrification in municipal WWTP

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WERF Nutrient Removal 3'

INNOVATIVE ECONOMY NATIONAL COHESION STRATEGY

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INTRODUCTION

The efficiencies of denitrification and enhanced biological phosphorus removal (EBPR) in biological nutrient removal (BNR) activated sludge systems are strongly dependent on the availability of appropriate carbon sources. There is a number of effective, commercially available organic compounds (such as methanol, ethanol, acetic acid, sodium acetate and glucose) which are categorized as the "conventional" external 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. Food industry effluents appear to be good candidates for this purpose due to their high C/N ratios and high content of readily biodegradable organic fraction.

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 (10-15 g TN/m^3).

PROJECT OVERVIEW

Funding	**European Regional Development Fund within the framework of the Innovative Economy Operational Programme 2007-2013 under the project no. UDA-POIG.01.03.01-22-140/09-01.**
Core team	Gdansk University of Technology, Poland (Jacek Makinia, Krzysztof Czerwionka, Katarzyna Jankowska, Marek Swinarski)
Scientific committee	Jan Oleszkiewicz, University of Manitoba, Winnipeg (Canada) H. David Stensel, University of Washington, Seattle Krishna Pagilla, Illinois Institute of Technology, Chicago Hansruedi Siegrist, EAWAG (Switzerland)
Status	Project started in January 2010
Completion	Anticipate final report in December 2012

INTRODUCTION

Ethanol produced in approximately 900 agricultural and 6 industrial distilleries and the total annual production is over 250 million L. During distillation, a few waste products are generated including fusel oil, reject water and syrup. The aim of this 3-year project is to use the distillery waste products as a carbon source for enhancing denitrification in the mainstream and sidestream treatment processes (Figure 1).

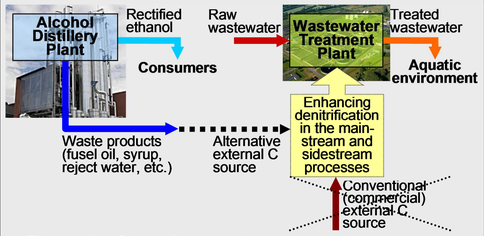

Figure 1 – Idea of the project

The project is run at the Gdansk wastewater treatment plant (570,000 PE), whereas the examined waste products originate from two local distilleries (Figure 2). The project tasks include kinetic and microbiological studies as well as computer simulation. The planned experiments are carried out at lab-scale (1st year), pilot-scale (2nd year) and full-scale (3rd year).

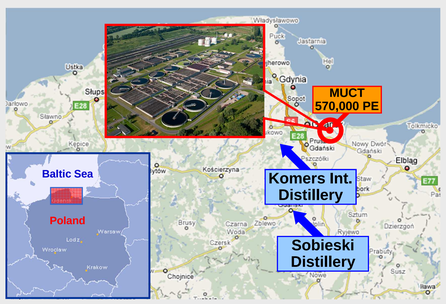

Figure 2 – Location of the distilleries and studied WWTP in Gdansk

KINETIC STUDIES

At lab-scale, the kinetic studies include measurements of the denitrification rate, acclimation period of microorganisms to specific carbon sources, and yield coefficient for these carbon sources. The experiments are carried out in a specially designed and constructed laboratory apparatus consisting of two batch reactors, automated control system and computer (Figure 3).

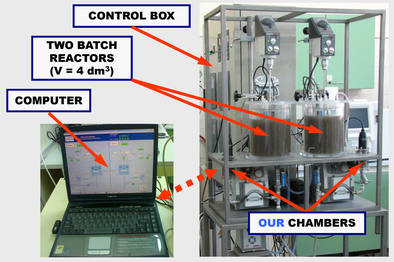

Figure 3 – Laboratory apparatus for conducting the kinetic studies

In one of the experiments, the acclimation of biomass to ethanol and fusel oil was investigated in the lab-scale reactors treating reject water in the "fill-and-draw" mode. The addition of both carbon sources resulted in a significant enhancement of the denitrification efficiency. The denitrification rates were raising from < 1 g N/(kg VSS·h) to >10 g N/(kg VSS·h) over a 4-week period (Figure 4). The overall TN reduction efficiency achieved the level of approx. 90%.

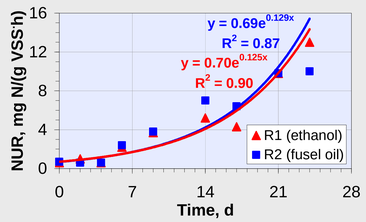

Figure 4 – Organic N fractions in the influents and effluents of the studied plants

MICROBIOLOGICAL STUDIES

The composition and dynamics of denitrifiers community as well as the quantitative analyses of the dominant microorganisms are investigated with respect to the examined carbon sources. The molecular analysis of DNA extraction, PCR amplification and DGGE separation are followed by the cluster analysis of DGGE patterns and display of phylogenetic trees (Figure 5). Sample results obtained during the acclimation period of denitrifiers to methanol and fusel oil are presented in Figure 6.

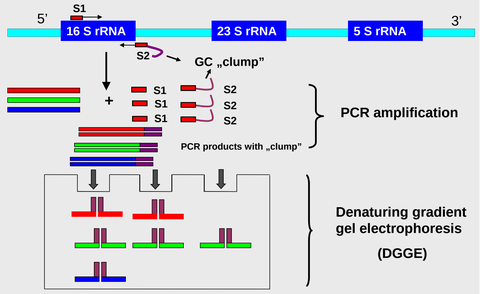

Figure 5 – Diagram showing the DGGE procedure

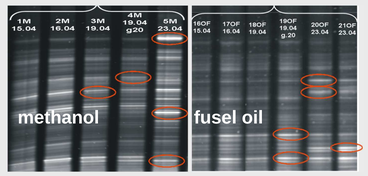

Figure 6 – Sample profiles of the PCR products

To investigate the phylogenetic identities of some dominant DGGE bands, these nucleotide sequences are compared with the sequences in Genbank using the BLAST program. With this knowledge, the appropriate 16S rRNA-targeted oligonucleotide probes are applied for quantitative detection of denitrifers using the combined methods of fluorescence in situ hybridization and cofocal laser scanning microscopy (FISH-CLSM).

FINDINGS

- Fusel oil and other distillery waste products appear to be an interesting alternative for commercial compounds, such as ethanol, when seeking an external carbon source for denitrification in activated sludge systems. The compounds are suitable for application in both mainstream and sidestream treatment systems.
- In the lab-scale experiments, the observed denitrification rates and yield coefficients for fusel oil were similar to ethanol.
- An acclimation period to fusel oil is required to improve the denitrification capability of process biomass. The effects comparable to a readily biodegradable fraction of wastewater can be observed within less than two weeks of acclimation.

BENEFITS / OUTCOMES

- Evaluation (supported by lab-, pilot- and full-scale investigations) of the properties of the distillery waste products as cost-effective "alternative" carbon sources for enhancing denitrification.
- Application of microbiological (molecular) methods, including DGGE and FISH, to identify and quantify the microbial groups responsible for denitrification in the mainstream and sidestream processes.
- Development of a mathematical model to characterize denitrifiers in terms of kinetic and stoichiometric parameters. The model will be used as a prediction tool to find optimal operating strategies for dosing external carbon sources.

INTERESTED IN COLLABORATING? PLEASE CONTACT:

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