

# Valorization of fish industry wastewater to bioenergy and microbial proteins

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My name is Pietro Postacchini, I am an Environmental Engineer specialized in biotechnology. Currently, as a postdoc at DTU, I am involved in research projects aiming at resource recovery from industrial wastewater.

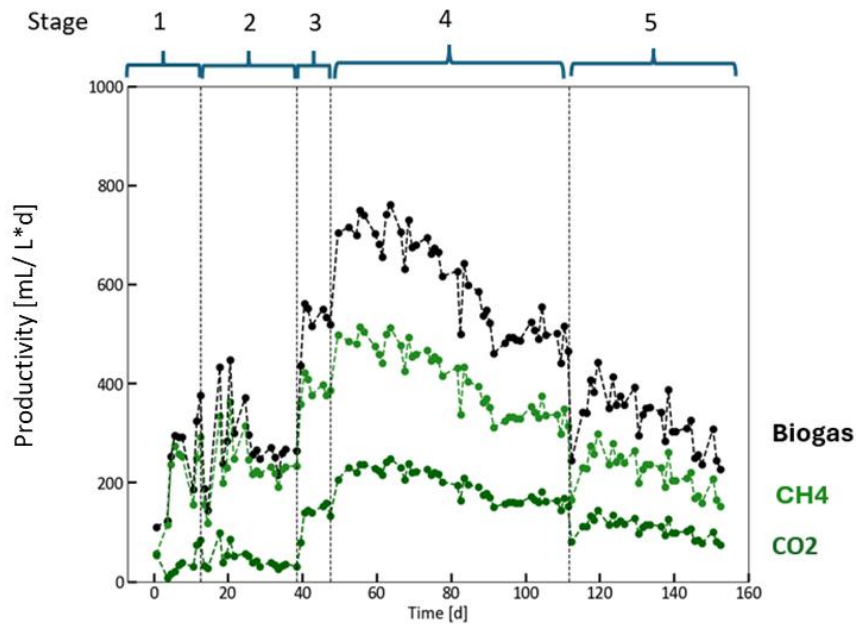
I would like to present the results of my experimental investigations of continuous anaerobic digestion (AD) of fish processing wastewater, electrochemical ammonia extraction from digestate, and microbial protein production by mixed hydrogen-oxidizing bacteria (HOB). HOB communities are particularly relevant for environmental protection as they enable CO<sub>2</sub> (originating from industrial flue gases) reduction and residual nutrients uptake.

The experimental setup consisted of a lab-scale continuously stirred-tank reactor (CSTR) for fish processing wastewater AD connected to a two-chamber electrochemical cell for online ammonia extraction. Extracted ammonia was used as nitrogen source for HOB cultivation (adapted from an inoculum taken from waterworks) in batch assays. Some of the cultures were exposed to flue gas impurities, including CO, NO<sub>x</sub>, SO<sub>x</sub>, to test their effects on microbial growth and protein yields.

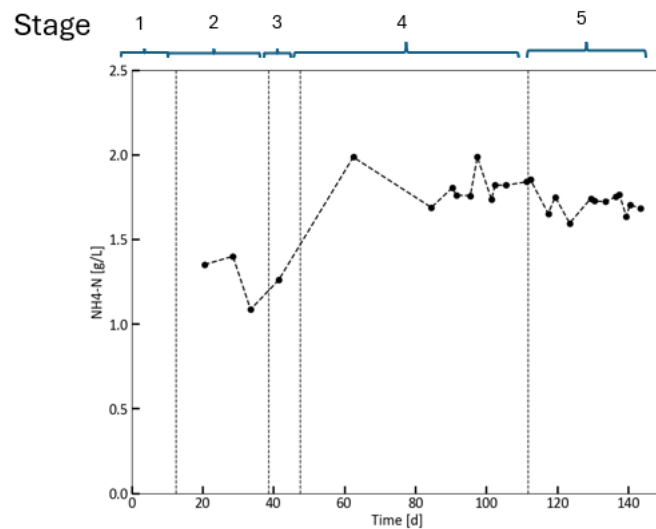
The fish processing wastewater was characterized as volatile solids (VS)  $7.02 \pm 0.04$  %, volatile fatty acid  $25 \pm 1$  g·L<sup>-1</sup>, Total-N  $14.82 \pm 1.5$  g·L<sup>-1</sup>. The resulting maximum methane yield on volatile solids (VS) obtained during AD (organic loading rate 1.2 g<sub>VS</sub>·L<sup>-1</sup>·d<sup>-1</sup>; HRT 15 d) was 404 mL·g<sub>VS</sub><sup>-1</sup>. Online electrochemical ammonium extraction achieved 20 % NH<sub>4</sub>-N recovery rate at 1.5 V. HOB cultures exhibited growth rate of 0.97 d<sup>-1</sup>, cell dry weight (CDW) yield on H<sub>2</sub> 2.1 g g<sup>-1</sup>, protein content on CDW 28.01 g g<sup>-1</sup>. Flue gas impurities (CO, NO<sub>2</sub>, SO<sub>3</sub>) had overall minimal effects on HOB growth and while CO affected protein yield (Figure 3).

Ongoing efforts focus on process optimization by modifying electrochemical cell configuration and on process performance assessment of continuous HOB cultivation. Process feasibility and life cycle assessments will also follow up.

## Figures and Tables



**Figure 1** Specific biogas, CH<sub>4</sub>, and CO<sub>2</sub> productivities over different operation stages. During Stage 1 to 4 the OLR was incremental, namely 0.4, 0.6, 0.9, 1.2 gvs·L<sup>-1</sup>·d<sup>-1</sup>. During Stage 5 OLR was 1.2 gvs·L<sup>-1</sup>·d<sup>-1</sup> and online electrochemical NH<sub>4</sub>-N extraction was performed at 1.5 V.



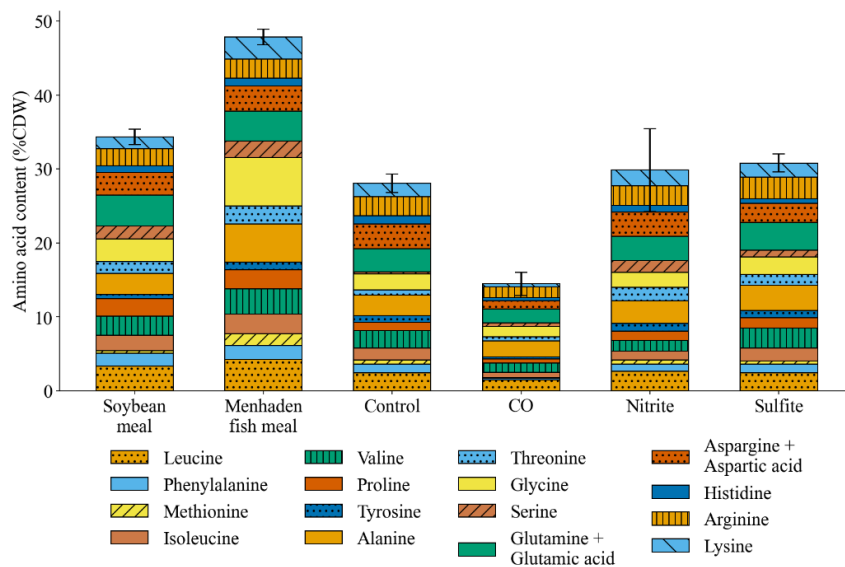
**Figure 2** Total ammonia concentration over different operation stages. During Stage 1 to 4 the OLR was incremental, namely 0.4, 0.6, 0.9, 1.2 gvs·L<sup>-1</sup>·d<sup>-1</sup>. During Stage 5 OLR was 1.2 gvs·L<sup>-1</sup>·d<sup>-1</sup> and online electrochemical NH<sub>4</sub>-N extraction was performed at 1.5 V.

**Table 1** Growth rate, H<sub>2</sub> uptake rate and CDW yield on H<sub>2</sub> of HOB batch cultures

Condition	Growth rate (d <sup>-1</sup> )	H <sub>2</sub> uptake rate (mg H <sub>2</sub> d <sup>-1</sup> )	Y <sub>CDW/H<sub>2</sub></sub> (g CDW g H <sub>2</sub> <sup>-1</sup> )
Control	0.97 ± 0.04	3.96 ± 0.28	2.10 ± 0.17
CO	1.54 ± 0.13	5.31 ± 0.85	2.18 ± 0.11
Nitrite	0.96 ± 0.10	5.75 ± 0.31	1.72 ± 0.16
Sulfite	0.81 ± 0.06	7.35 ± 0.71	2.34 ± 0.13

**Table 2** Protein content of CDW of HOB batch

Batch	Total protein (% CDW)
Soybean meal	34.33 ± 1.02
Menhaden fish meal	47.86 ± 1.04
Control	28.07 ± 1.25
CO	14.46 ± 1.56
Nitrite	29.84 ± 5.60
Sulfite	30.81 ± 1.20



**Figure 3** Amino acid profile of protein content (HOB batch cultures).