# N-DAMO process package: Evaluation for N-DAMO in wastewater treatment plant

## 1. Background:

There are two problems frequently discussed in operating biological process in the wastewater treatment plants. The first problem is methane emission problem. Methane is produced in the anaerobic digestion process in the wastewater treatment plants. As a greenhouse gas, the emission of methane in the wastewater treatment plants accelerates the extent of global warming. The second problem is carbon deficiency in the denitrificatioin process. Denitrification is an important process required in the wastewater treatment plants for removing nitrite/nitrate nitrogen in the wastewater. Wastewater containing nitrite/nitrate will cause severe environmental problem, such as eutrophication. Denitrification conducted by organisms called denitrifiers require organic carbon as electron donor to convert nitrite/nitrate to nitrogen. Wastewater contains carbon contaminants can be served as carbon source for denitrification process. However, the carbon is depleted by the biological process prior to denitrification process, which builds the gap for removing nitrite/nitrate in the wastewater. Nitrite/nitrate dependent anaerobic methane oxidation (N-DAMO) organisms have been widely proposed as the solution of these two problems existing in the wastewater treatment plants. N-DAMO organisms are able to use methane as carbon source and electron donor. Although several studies point out the potential for using anaerobic effluent (which has potential of producing dissolved methane) as the carbon source for enriching N-DAMO organisms to denitrify, there is no wastewater treatment plant actually conducting this idea. It is possible that changing operation process will lead to dramatic changes of organisms in the biological process and further decreases denitrification performance. As a result, the idea of this project is to design a package, which can preliminary evaluates the denitrification performance if we apply N-DAMO organisms in the wastewater treatment plant.

N-DAMO organisms include N-DAMO archaea and N-DAMO bacteria. N-DAMO archaea can use methane and convert nitrate to nitrite (equation 1), while N-DAMO bacteria can use methane and convert nitrite to nitrogen (equation 2). The chemical reactions of N-DAMO organisms are shown below. N-DAMO reactions spontaneously occur. The reaction rate, rate constants and nitrite/nitrate affinity are simplified and referenced from the literatures in this project(Lu et al. 2019; He et al. 2013).

$$4NO_3^- + CH_4 \rightarrow 4NO_2^- + CO_2 + 2H_2O \qquad (1)$$

$$8NO_2^- + 3CH_4 + 8H^+ \rightarrow 4N_2 + 3CO_2 + 10H_2O \qquad (2)$$

## 2. User profile:

The target users are the civil engineers working in the wastewater treatment

plant to preliminary evaluate the denitrification performance for switching to N-DAMO organisms for denitrification. They need to have basic understanding on python, so they will be comfortable to work in Collab or similar notebook environments. I plan to write a code for them to open the spreadsheet with water quality parameters, which are frequently collected in the wastewater treatment plants. In the end of the package, the users can get a sentence showing that N-DAMO process does not exist, or the users can get a figure of the N-DAMO modeling result.

**3. Use cases:**

**Use case1:** Assessing the production of dissolved methane involves examining the provided spreadsheet to determine whether the wastewater has the potential to undergo the N-DAMO process. To achieve this goal, the user will need to provide the spreadsheet with different columns of water quality parameters. The index of the data is time in days. The column of Biological Oxygen Demand (BOD) will be selected for estimating potential of methane production. Dissolved methane is the final parameter for N-DAMO process evaluation. Different water quality parameters, such as salinity and temperature will also be used to calculate the amount of dissolved methane. The first interaction for this use case is that I will compare the minimum value of calculated dissolved methane from the spreadsheet with 1 mmol/L, which is the postulated value of N-DAMO archaea (He et al. 2013). If the minimum value of calculated dissolved methane is larger than 1, a sentence “N-DAMO process exists” will show up in the terminal (If you use VS code). The package will move on to complete second goal. If the minimum value of calculated dissolved methane is smaller than 1, a sentence “N-DAMO process does not exist” will show up in the terminal. The programming will terminate.

**Use case2:** Import the minimum dissolved methane value for evaluating the nitrite and nitrate concentration by N-DAMO process. Tellurium will be used for modeling. The civil engineer can decide import concentration of nitrite and nitrate (unit is mmol/L), and adjust the ratio of wastewater input for modeling. The interaction of user and use case is a figure of nitrite, nitrate, nitrogen and methane concentration over time showing up. Civil engineer can have roughly judgement if they can switch N-DAMO process from the figure based on the water quality data they provide.

Reference

He, Zhanfei, ChenCai, ShaGeng, LipingLou, XiangyangXu, PingZheng, andBaolanHu. 2013. “Mdodeling a Nitrite-Dependent Anaerobic Methane Oxidation Process: Parameters Identification and Model Evaluation.” *Bioresource Technology* 147: 315–20. https://doi.org/10.1016/j.biortech.2013.08.001.

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