MIT - Data Science JG19 - Master Thesis

Modeling of the microbial functional diversity during waste degradation

Christian Brandstätter

Conclusions

By investigating MSW-waste degradation of old landfilled waste with Biolog® EcoPlates™ , it was possible to link the metabolic activity of the microbial consortium with the reactivity of the material. Namely, the potential for growth and respiration on carbohydrates (positively) and the potential for utilizing polymers (negatively) both impacted the RI_4.

An article was submitted to the journal *Biogeochemistry* and the dataset itself was published on *Zenodo* [1].

Introduction

The microbial degradation of landfilled solid waste material is a driving force for occuring emissions. In a two year laboratory experiment, this degradation process was investigated. One well established way of describing the capability of a microbial community to utilize different nutrient sources is the usage of Biolog® EcoPlates™ [2]. Major challenges for the method are data analysis and extraction as well as setting up standardized laboratory conditions.

In the here presented work, the Biolog® EcoPlates™ results were linked with standardized biodegradation tests to achieve a better understanding of the underlying process itself. For the analysis roughly 36*2*96*5 (samples*solid/leachate*measure-vials*time-points) = **34,560 data points** were considered. For each sample after averaging the technical replicate, 100 data points were created by interpolation. As baseline for the heuristic fitting of the Gompertz-curves, roughly **223,200 data points** were created.

Materials and Methods

For conducting dynamic monitoring of the functional diversity of the respective samples over six days the Biolog® EcoPlates™ method was used. Every EcoPlate consisted of 96 wells containing 31 different carbon sources plus a blank well in three replications each.

For calculating the total substrate consumption a Gompertz-equation was fitted by using the grofit package [3]. The Grofit-equation commonly used [4] is derived as follows:

$$y = A \exp\left\{-\exp\left[\frac{\mu e}{A}(\lambda - t) + 1\right]\right\} \quad (1)$$

with A being the asymptote (amplitude), μ being the linear slope (or growth rate), e being Euler's number and λ being the lag time. Prior to the calculation of the Gompertz-curve (equation 1), spline interpolation was conducted. For the interpolation, the total time period of 96 hours was divided in 100 data points based on the measured data points.

The respiration index after four days (RI_4) was measured according to the Austrian standard ON S 2027-4:2012-06-01.

Results

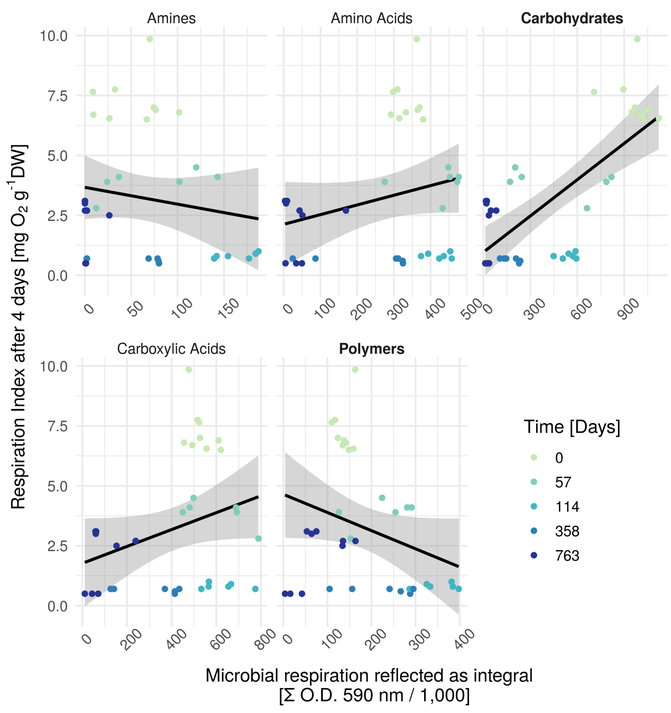

Figure 1: Respiration Index vs. Ecoplates

By investigating the relationship between the Biolog® EcoPlates™ results and the RI_4 (see Fig. 1) the following model was found:

$$RI_4 = 0.26 + 0.68 * Carbohydrates - 0.5 * Polymers \quad (2)$$

with Carbohydrates and Polymers representing the standardized integrated O.D. at 590 nm after 96 hours derived from the Gompertz-Model. The model was based on 36 observations and the intercept and every parameter showed a p-value below 0.001. The adjusted R^2 for the model was 0.69.

References

[1] C. Brandstätter, N. Fricko, J. Fellner, M. J. Rahimi, and I. S. Druzhinina, *Mintox - Dataset Ecoplates*, 2021.

[2] J. L. Garland and A. L. Mills, "Classification and characterization of heterotrophic microbial communities on the basis of patterns of community-level sole-carbon-source utilization", Applied and Environmental Microbiology **57**, 2351–2359 (1991).

[3] M. Kahm, G. Hasenbrink, H. Lichtenberg-Fraté, J. Ludwig, and M. Kschischo, "Grofit: Fitting biological growth curves with R", Journal of Statistical Software **33**, 1–21 (2010).

[4] M. H. Zwietering, I. Jongenburger, F. M. Rombouts, and K. van 't Riet, "Modeling of the bacterial growth curve.", Applied and environmental microbiology **56**, 1875–81 (1990).

[5] ON S 2027-4:2012-06-01, *Evaluation of waste from mechanical-biological treatment - Part 4: Stability parameters - Respiration activity (AT4)*, 2012.

Acknowledgments

Big thanks to Philipp Aschenbrenner for tremendous laboratory support and to Christian Derntl (ICEBE, TU Wien, Vienna, Austria) for the support for laboratory work during pandemic lockdown. This research was funded by the Austrian Science Fund FWF - Project number P 29168 to Johann Fellner.

Advisor: DI Wolfgang Ecker-Lala
Author e-mail: bran.chri@gmail.com