New Biotechnology 33 (2016) 852–859

Contents lists available at ScienceDirect

New Biotechnology

journal homepage: www.elsevier.com/locate/nbt

Full length article

Evaluating robustness of a diesel-degrading bacterial consortium isolated from contaminated soil

Mateusz Sydow[a,*], Mikołaj Owsianiak[b], Zuzanna Szczepaniak[c], Grzegorz Framski[d], Barth F. Smets[e], Łukasz Ławniczak[a], Piotr Lisiecki[a], Alicja Szulc[a], Paweł Cyplik[f], Łukasz Chrzanowski[a]

[a] Institute of Chemical Technology and Engineering, Poznan University of Technology, Berdychowo 4, 60-965 Poznań, Poland
[b] Division for Quantitative Sustainability Assessment, Department of Management Engineering, Technical University of Denmark, Produktionstorvet, Building 424, DK-2800 Kgs. Lyngby, Denmark
[c] Institute of Food Technology of Plant Origin, Poznan University of Life Sciences, Wojska Polskiego 31, 60-624 Poznań, Poland
[d] Institute of Bioorganic Chemistry, Polish Academy of Sciences, Noskowskiego 12/14, 61-704 Poznań, Poland
[e] Department of Environmental Engineering, Technical University of Denmark, Miljøvej, Building 113, DK-2800 Kgs. Lyngby, Denmark
[f] Department of Biotechnology and Food Microbiology, Poznan University of Life Sciences, Wojska Polskiego 48, 60-627 Poznań, Poland

A R T I C L E I N F O

Article history:
Received 26 January 2016
Received in revised form 23 August 2016
Accepted 23 August 2016
Available online 25 August 2016

Keywords:
Biodegradation
Community dynamics
Hydrocarbon
Robustness
Resilience

A B S T R A C T

It is not known whether diesel-degrading bacterial communities are structurally and functionally robust when exposed to different hydrocarbon types. Here, we exposed a diesel-degrading consortium to model either alkanes, cycloalkanes or aromatic hydrocarbons as carbon sources to study its structural resistance. The structural resistance was low, with changes in relative abundances of up to four orders of magnitude, depending on hydrocarbon type and bacterial taxon. This low resistance is explained by the presence of hydrocarbon-degrading specialists in the consortium and differences in growth kinetics on individual hydrocarbons. However, despite this low resistance, structural and functional resilience were high, as verified by re-exposing the hydrocarbon-perturbed consortium to diesel fuel. The high resilience is either due to the short exposure time, insufficient for permanent changes in consortium structure and function, or the ability of some consortium members to be maintained during exposure on degradation intermediates produced by other members. Thus, the consortium is expected to cope with short-term exposures to narrow carbon feeds, while maintaining its structural and functional integrity, which remains an advantage over biodegradation approaches using single species cultures.

Introduction

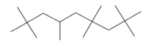
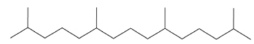
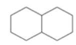
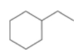
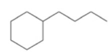
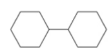
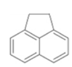
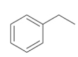
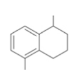
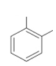
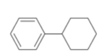
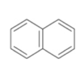
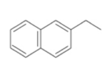
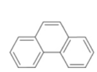
Selection of microbial communities for bioaugmentation of soils contaminated with hydrocarbon mixtures, such as diesel fuel, must consider their ability to adapt to temporal changes in hydrocarbon composition over the course of biodegradation [1,2]. Similarly, if bioremediation relies on the activity of autochthonous microorganisms, temporal changes in community structure and function can occur [3–5]. The ability of microbial communities to resist such potentially irreversible changes is one of the factors determining the success of bioremediation [6]. This ability, often referred to as robustness, is usually characterised by investigating: (i) the ability of a community to resist a change in its structure after perturbation, and (ii) the potential for recovery of the community's structure to its initial state after removal of the perturbation. These two indicators of structural robustness are referred to by the terms *structural* resistance and *structural* resilience, respectively [7,8]. The structure of a community may also influence its *functional* robustness, understood as the ability of a community to maintain a particular activity despite perturbation [7,9,10].

Vila et al. showed that successive biodegradation of particular hydrocarbon fractions in the marine environment is conducted by different, temporally dominant bacterial taxa [11]. Also Kostka et al. showed that *Alcanivorax* was the dominant taxon during linear and branched alkane utilisation in the early stages of crude oil biodegradation in a marine environment, whereas *Acinetobacter*, *Marinobacter* and *Pseudomonas*, identified as both alkane and aromatics degraders, were the most abundant at the later stage of biodegradation [2]. Diesel-degrading consortia are similarly not thought to consist of generalist bacteria with an ability of growth on all major hydrocarbon types (that is, linear and branched alkanes, cycloalkanes and aromatic hydrocarbons)

* Corresponding author.
E-mail address: mateusz.sydow@gmail.com (M. Sydow).

http://dx.doi.org/10.1016/j.nbt.2016.08.003
1871-6784/

Table 1
The list of used carbon sources during the study.

Compound:	Structure:	Nominal concentration [mg mL^{-1}]:
alkanes		
dodecane		5
hexadecane		5
octadecane		5
docosane		5
heptamethylnonane		5
pristane		5
cycloalkanes		
decalin		5
cycloheptane		5
ethylcyclohexane		5
butylcyclohexane		5
bicyclohexyl		5
aromatic hydrocarbons		
acenaphthene		5
ethylbenzene		5
1,5-dimethyltetraline		5
o-xylene		5
cyclohexylbenzene		5
naphthalene		5
2-ethylnaphthalene		5
phenanthrene		5
alkanes mixture		
dodecane, hexadecane, octadecane, heptamethylnonane, pristane	see above	5[a]
cycloalkanes mixture		
decalin, ethylcyclohexane, butylcyclohexane, bicyclohexyl	see above	5[b]
aromatic hydrocarbons mixture		
ethylbenzene, o-xylene, naphthalene, 2-ethylnaphthalene, phenanthrene	see above	5[c]