Oil biodegradation and microbial ecology within permeable pavements

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Abstract

Previous research into the properties of laboratory-based permeable pavement structures (PPS) demonstrated that PPS could be turned into powerful *in-situ* aerobic bioreactors capable of trapping and degrading large quantities of clean mineral oil. However, information on the microbial community known to be responsible for the biodegradation function of PPS was limited. A two-year old oil-degrading PPS maintained effective oil retention and biodegradation for a further two years and demonstrated resilience after drought and nutrient depletion. Inoculation of PPS rigs with Biotreat HD™ oil degrading microbial suspension was shown not to facilitate more biodegradation than PPS rigs without an addition of adapted microorganisms.
The structure of a mature oil-degrading biofilm was revealed by scanning electron microscopy.

Bacteria and fungi supported a considerable diversity and abundance of protozoa, known to be the primary consumers of decomposers in microbial food-webs. Members of all four of the functional groupings of protozoa, microflagellates, gymnamoebae, ciliates and testate amoebae were identified, in addition to small metazoans.

The source of protozoan diversity was shown to be the original PPS construction materials bearing microorganisms in a dormant or encysted form. Differences between around optimal and sub-optimal abiotic conditions, in particular environmental temperatures, strongly influenced protozoan community development.

Removal of prokaryotes or eukaryotes using filtration, dilution and antimicrobial agents resulted in reduced biodegradation, suggesting that all members of the PPS community have a role in the biodegradation process. Predatory eukaryotes are thought to play a role in the maintenance of the free-draining geotextile, nutrient recycling and regeneration.

Replacement of a granite PPS sub-base with recycled concrete raised the PPS effluent to a pH value of 9. Differences of oil-in-effluent in granite and concrete rigs were minimal. Increased abundances of metazoa were observed in concrete-based rigs in comparison with granite. Protozoan diversity was higher in granite rigs than concrete rigs, but diversity in both rig types was greater with an oil application rate of 900 grams/m^2 than in previous experiments with lower oil application rates.

A reduction in nutrient inputs to future field-based PPS may be made possible by the analysis of nutrients brought to the PPS from diffuse environmental sources.

Permeable pavements are now known to require fewer inputs to operate efficiently than previously thought. Microbial oil degraders and nutrients are present in PPS rigs and field car park installations and this should reduce maintenance costs, increasing the attractiveness of the PPS as a drainage solution. The possibility of using recycled materials with little effect on the microbial community should also reduce costs. Significant advances in oil protistology have been made, including discovery of the potential of protists to be used as environmental indicators in monitoring hydrocarbon contamination.

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