**Antimethanogenic Supplements for ERD Amendments**

Chris Nelson, Jim Mueller (Provectus Environmental Products, Inc.) and John Haselow (Redox-Tech, LLC)

**INTRODUCTION**
Enhanced reductive dehalogenation (ERD) has demonstrated success in the *in situ* remediation of numerous sites impacted by various constituents, most commonly chlorinated ethenes. One seemingly universal phenomenon has been the biological production of methane, especially during the early phases of the process. There are recognized benefits to methanogens and of limited methanogenesis; however, excessive methane production represents a costly waste of amendment (generating just 20 mg/L of methane constitutes greater than 33% of the total amendment consumption based on moles of H2; Mueller et al., 2014). Moreover, excessive and extended production of methane can result in elevated groundwater concentrations (as high as ca. 1,000 ppm have been reported) which can lead to accumulation in soil gas subsequently impacting indoor air, accumulating in basements, under slabs/foundations and/or migrate along utility corridors. Accordingly, State-specific regulations for methane in groundwater have been promulgated, and remedial practitioners proactively design costly contingencies for conventional ERD implementation in the event that methane exceeds a threshold level ranging from 1 to 10 ppm groundwater.

**APPROACH**
Active measures to control the production of methane can offer multiple advantages in terms of cost, treatment efficiency, treatment time and safety. Such measures have included the use of slowly released carbon sources, excess nitrate/sulfate, ethylsulfonates, ethylfomate, low level toxins, et cetera but these are not specific to methanogens and the efforts have met with limited success. Recently, the use of statins as effective inhibitors of protein and enzyme systems specific to Archaea (i.e., methanogens) was described for environmental applications (Scalzi et al., 2013, 2014).

**WHAT IS A METHANOGEN?**
- Methanogens are microorganisms that produce methane
- They are ubiquitous, and they are often dominant in numbers, averaging 2% to 15% of all soil microbes
- They are important members of synergistic, fickle anaerobic communities
- They are genetically unique and belong to their own domain, Archaea
- They can double cell numbers in one hour and are problematic when overactive

**HOW CAN WE CONTROL METHANOGENS?**
- Provect-CH4™ is a proprietary amendment for environmental remediation applications that includes Red Yeast Rice (RYY) Extract. RYY extract contains a number of natural statin compounds, including Monacolin K (also known as Lovastatin), that effectively inhibit methanogens while permitting other biodegradation processes to occur.
- Mode of Action: Research has demonstrated that these statins specifically inhibit the growth and development of Archaea hence minimizing methanogenic activity. Bacteria cell walls contain peptidoglycan (murein), whereas the cell walls of methanogens cell walls contain pseudomurein.

Pseudomurein is biosynthesized via activity similar to that of 3-hydroxy-3-methylglutaryl-coenzyme A (HMG-CoA) reductase, which is a key enzyme in the cholesterol biosynthesis pathway in humans. In the presence of Monacolin K and other statins in Provect-CH4™ HMG-CoA reductase is inhibited, pseudomurein biosynthesis pathway is interrupted, and methanogens are restricted from growth, development and proliferation.

**ANTIMETHANOGENIC TECHNOLOGIES**
We integrated methane control features into various amendments to create safer, more efficacious remedial technologies (see below).