

# Long-Term Performance and Methanogenesis Associated With Four Remedial Amendments – Indiana Sites

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## INTRODUCTION

There are recognized benefits to methanogens and of limited methanogenesis. For example: i) methanogens are known to play important roles in synergistic microbial ecology, ii) their metabolic activity can help maintain anoxic conditions in treatment zones (through seasonal changes), and iii) the activity of methane mono-oxygenases and other enzymes can stimulate metabolic activity in redox-recovery zones. However, excessive methane production can have potential negative consequences, including:

- Loss of efficiency (Evolution of CH<sub>4</sub> represents a costly waste)
- Induced vapor migration
- Induced heavy metal mobilization (via methylation)
- Failure to adhere to regulatory guidelines

Excessive and extended methanogenesis has been observed at multiple remediation sites where conventional (i.e., no active methane control technology) ERD and ISCR amendments have been utilized. Accordingly, State-specific regulations for methane in groundwater have been promulgated, with IDEM offering a leading role in the effort. Methane exceedance threshold values ranging from 1 to 10 ppm groundwater have been proposed. The State of Indiana (along with numerous other states). As a result, many remedial practitioners now proactively manage methanogenesis or provide contingencies for managing gas production when using conventional ERD or ISCR amendments.

## ANTIMETHANOGENIC REAGENTS (AMR)

Alternative means of controlling excessive methanogenesis are being studied and evaluated. These include refinements in donor application (types or amendments and dosages) and the use of methane control technologies. **Provect-CH<sub>4</sub>**® provides a unique source of Monacolin K and other natural statins that interfere with the biosynthesis of pseudomurein (found only in Archaea) which prevents cell wall biosynthesis. Likewise, certain essential plant oils (e.g., garlic oil) interfere with biochemical functions unique to Archaea. Hence, in the presence of AMRs, the growth and proliferation of methanogens is specifically limited (i.e., this inhibitory affect is not observed in other microbes as determined by catabolic reactions (Figure 1). This potentially allows slower-growing *Dehalococcoides* spp. to better compete

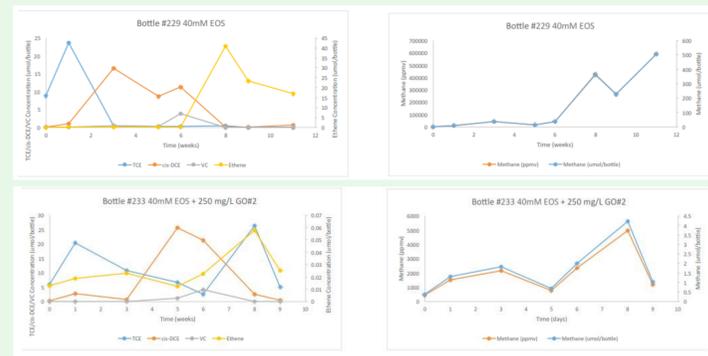


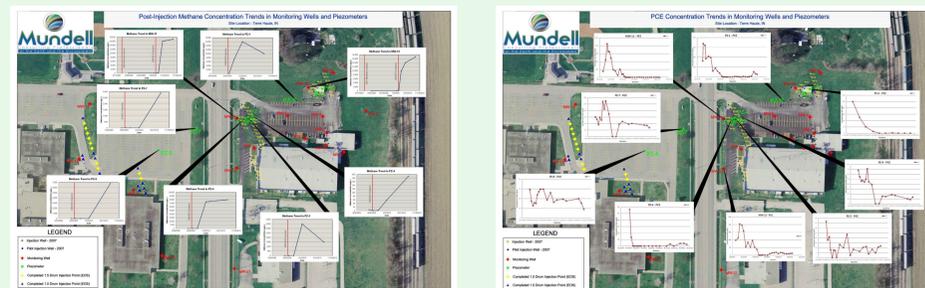
Figure 1. TCE removal (left panels) and CH<sub>4</sub> production (right panels) using EVO without AMR (top) and with AMR (bottom)

## TERRE HAUTE – Former Printing and Manufacturing Facility

Site impacted by PCE and associated daughter products. The highest impact levels were observed on-site, at maximum cVOC concentrations of around 12,000 ug/L. Groundwater impacts extended from the site, under a school and residential area with drinking water wells. Groundwater at ~25 ft below ground surface (ft-bgs) with sandy vadose zone ~5 to 10 ft-bgs.

**Injected:** Molasses (1,840 lbs of 100% product) (Pilot Test)  
Emulsified Vegetable Oil (4,510 lbs EOS@ 60% EVO)  
No active methane control

**Results:** After 3 years 90% of site COCs were removed, but 17 ppm of methane was observed in the treatment area and 7 ppm off-site.

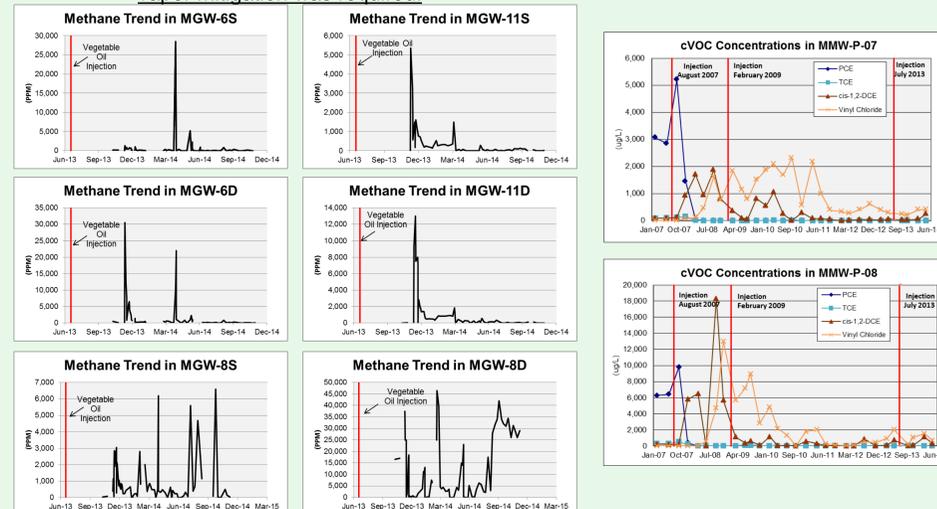


## INDIANAPOLIS – Former Dry Cleaning and Manufacturing Facility

Site impacted with PCE and associated daughter products. The highest impact levels were observed on-site, at a maximum cVOC concentrations of 10,000 ug/L. Groundwater impacts extended into a mixed commercial residential area. Groundwater at 15 ft-bgs. Geology is mainly sand, underlain by a lateral continuous till layer. Remediation at the site also included AS-SVE systems.

**Injections:** Neat Vegetable Oil (6,100 lbs CAP-18® at 100% product) (pilot)  
Neat Vegetable Oil (16,575 lbs CAP-18® at 100% product)  
Neat Vegetable Oil (17,000 lbs CAP-18® at 100% product) (supplementary)  
No active methane control

**Results:** 80% of site COCs removed, but >45,000 ppm of methane observed and active and passive vapor mitigation was required.

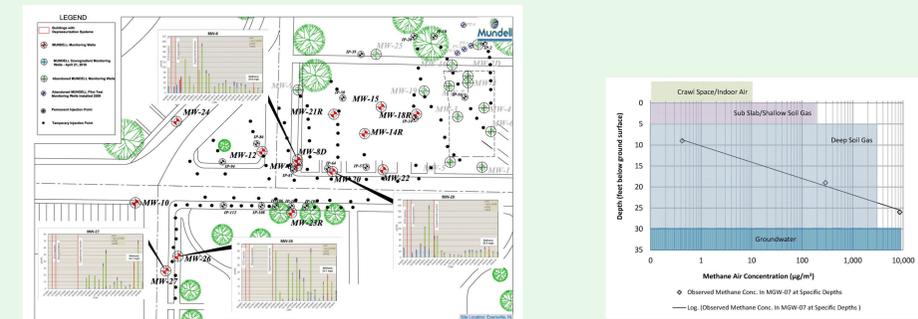


## EVANSVILLE – Former Dry Cleaner

Site impacted by PCE and associated daughter products. The highest impact levels were observed on-site, at maximum cVOC concentrations of 14,000 ug/L. Groundwater impacts from the site extended into a mixed commercial and residential area. Groundwater at 25 ft-bgs with a silty sand geology. The site was remediated with an air-sparge soil vapor extraction system (AS-SVE) and injections.

**Injections:** Emulsified Vegetable Oil (83,160 lbs EOS@ at 60% EVO)  
BAC-9TM Bio-Augmentation Bacteria (640 lbs)  
Combined Emulsified Vegetable Oil and Bio-Augmentation Bacteria (12,500 gallons of 10% diluted EOS@) (supplemental)  
No active methane control

**Results:** 90+% of site COCs removed, but >25 ppm of methane observed in groundwater and >13,000 ppm methane vapor in soil gas at 26 ft-bgs.



## SEYMOUR – Former Manufacturing Facility

Site impacted by PCE and associated daughter products. The highest impact levels were observed on-site, at maximum cVOC concentrations of 60,000 ug/L. Groundwater impacts from the site extend into a residential area. Groundwater at 5 ft-bgs. Geology is mixed, with a large sand unit and interspersed layers of clay and silt. Remediation at this site prior to injections included a large excavation with thermal treatment of soil.

**Injections:** ISCR (28,850 lbs of EHC®) (original treatment)  
Emulsified Vegetable Oil (52,500 lbs EOS@ at 100% EVO)  
Emulsified Vegetable Oil (9,240 lbs EOS@ at 100% EVO) (supplemental)  
Both EVO injections included Provect-CH<sub>4</sub>® antimethanogenic reagent

**Results:** 85+% of site COCs removed with only 1.9 ppm of methane observed on-site.

