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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 (CH₄ represents waste)
- Induced vapor intrusion issues
- Induced plume migration
- Mobilization of heavy metals (methylation)
- Failure to adhere to regulatory guidelines
- Various health & safety issues

Accordingly many remedial practitioners proactively manage excessive methanogenesis, or provide contingencies for managing gas production when using conventional ERD or ISCR amendments.

ANTIMETHANOGENIC REAGENTS (AMRs)

Provect-CH₄® provides a unique source of natural statins that interfere with the biosynthesis of pseudomurein (found only in Archaea). Likewise, other compounds with extended longevity similarly interfere with biochemical functions unique to Archaea (US Patent 9,221,699; patents pending). 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). This potentially allows slower-growing *Dehalococcoides* spp. to better compete = potentially more efficient.

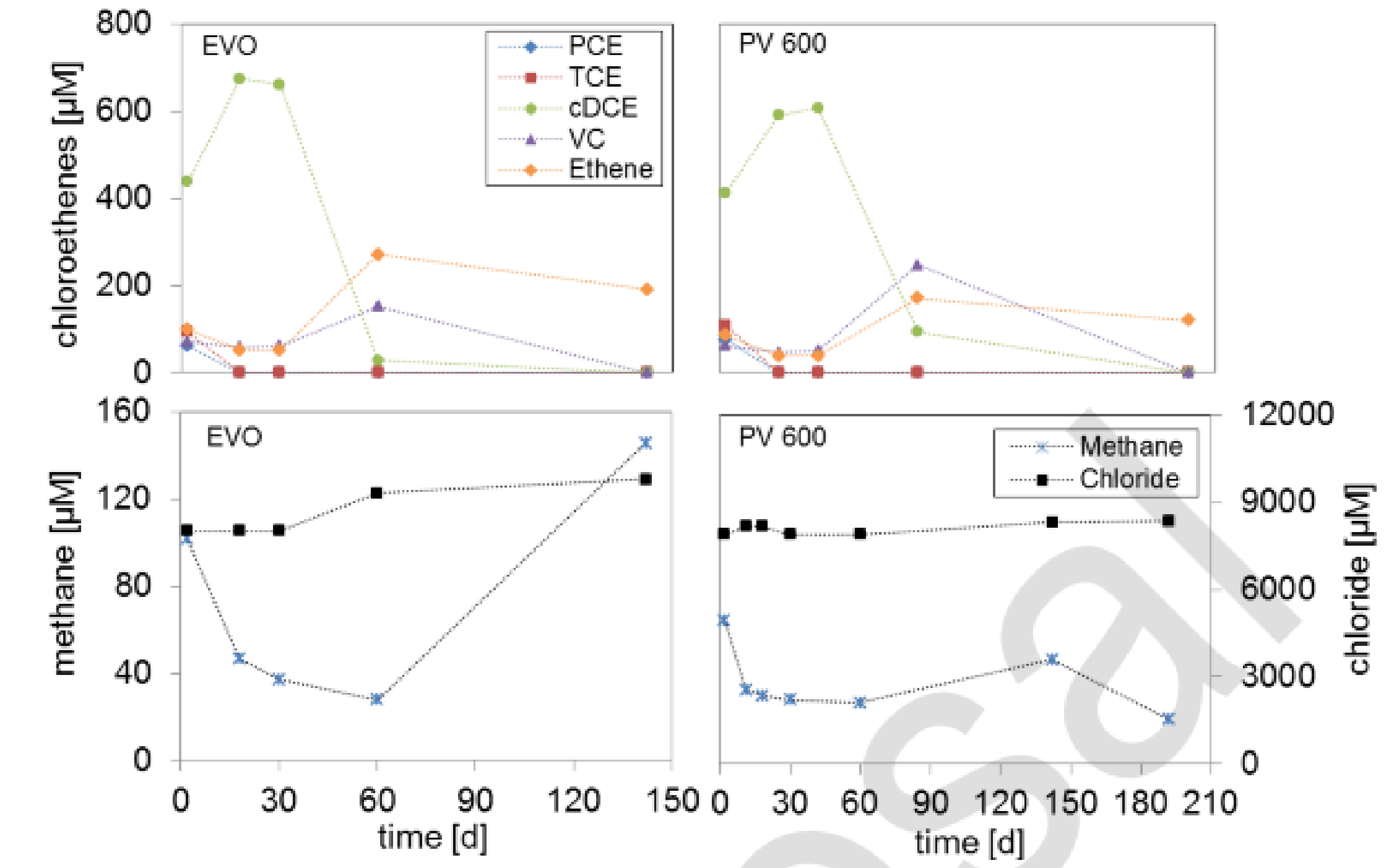


Figure 1a. TCE removal (left panels) and CH₄ production (right panels) using EVO 40 mM without AMR (top) and with AMR 250 mg/L (bottom).

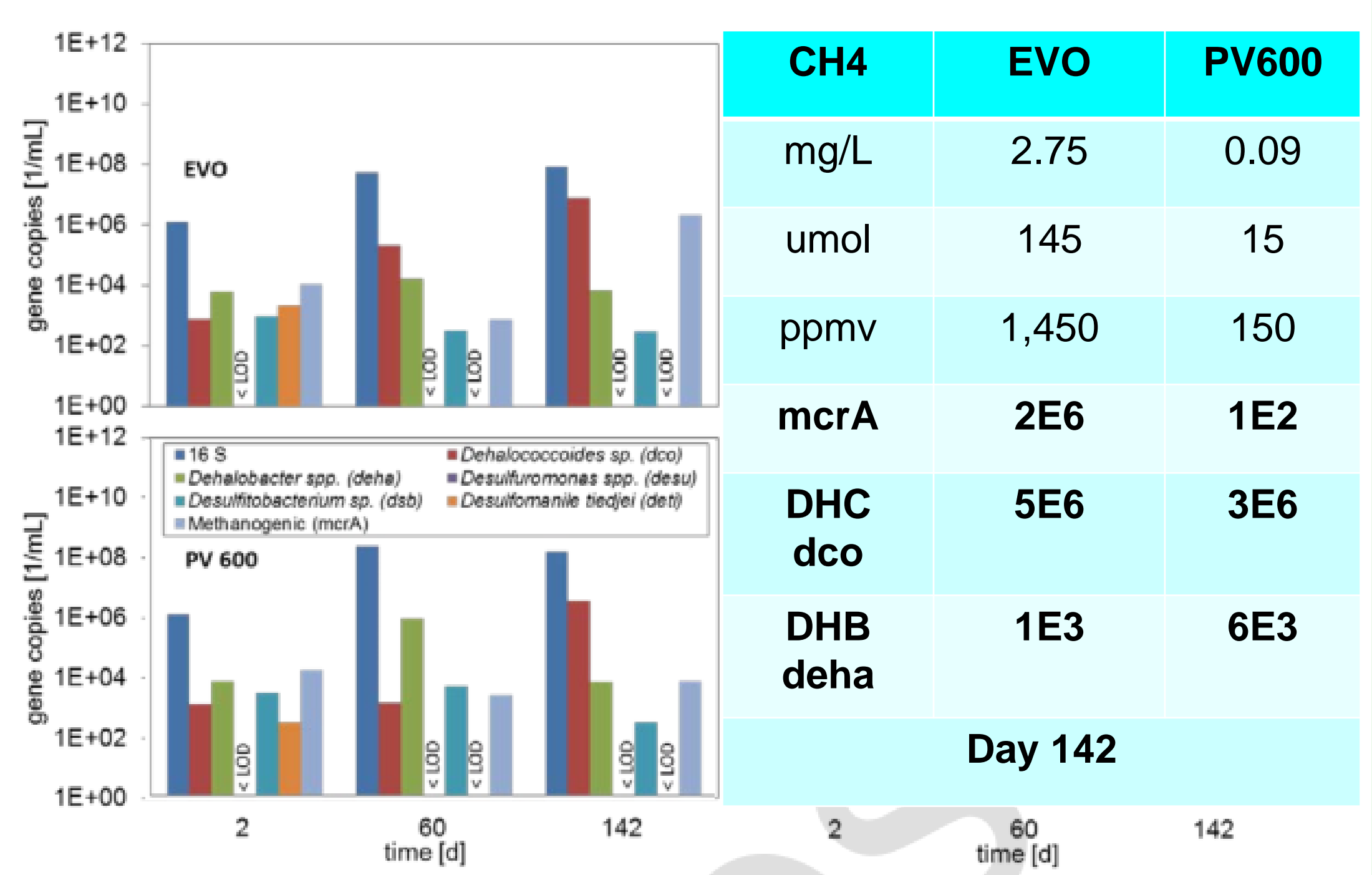
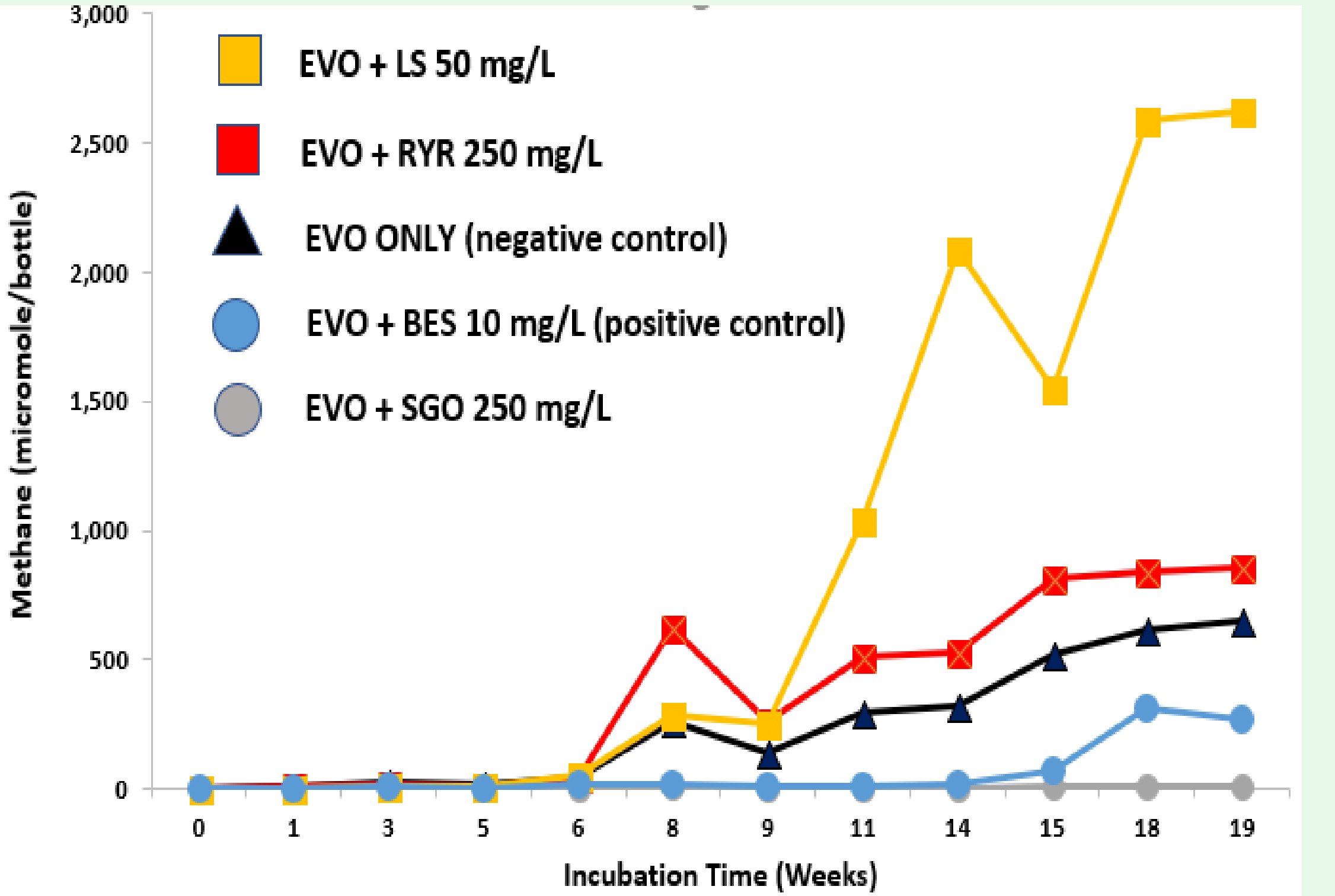


Figure 1b. qPCR results for EVO with (PV600) and without (EVO) Provect-CH₄ AMR technology (LOD < 10 copies/mL).



Effect of Select AMRs on Methanogenesis in the Presence of 40 mM EVO (ca. 8,000 ppm) as the OHD / Fermentable Carbon Substrate (>19 weeks incubation time; n=2).

Source Figures 1a and 1b – DVGM, Germany

ANTIMETHANOGENIC LIQUID ERD

Provect-ERD CH₄ Ole Ego™ (plus DVI)



- Specific Gravity = 1.00 to 1.2
- Density 7.75 to 8.36 lbs/USG
- Hydrogen Yield= 0.2 g to 0.4 H₂/g
- Fermentable carbon @ 65-90% wt
- AMR @ 4 - 8% of the FC content
- Optional DVI soluble, organic Fe content @ 5 to 10% wt
- Made in the USA

Photograph 1. Provect-ERD CH₄™ 15:1 Water:Oil (Left), 85% Carbon + 4% AMR Self-Emulsifiable Oil Concentrate (Middle), and 85% Carbon Self-Emulsifiable Oil Concentrate, no AMR (Right).

Product Data

The materials are all combined at our own manufacturing facilities in the USA (and Europe) at proportions and formulations optimized for a given site. ERD-CH₄™ is manufactured using 100% food grade ingredients that provide fast- and slow-release characteristics. Provect-CH₄® antimethanogenic reagent (AMR) is typically added at three to five weight percent of the mass of the fermentable carbon. The common dosage of ERD-CH₄ provides groundwater concentrations of 1,000 to 3,000 ppm TOC plus a minimum 150 ppm of AMR within the targeted treatment area.

Color	Translucent Yellow								
Density (lbs. / gal)	7.75 to 8.46 (varies based on AMR)								
Physical State	Liquid								
Odor	Earthy								
Viscosity (Brookfield, 30 rpm @25°C)	50-100 cps								
pH – 1% w/v in water	7.3								

Oil Sample	Al	P	S	Zn	Fe	Mg	Ca	Na	K
Self-Emulsifiable Vegetable Oil	1.2	1,265	17.2	19.6	1.4	138	135	15.4	507
	to	to	to	to	to	to	to	to	to
	1.3	1,751	28.2	39.7	2.3	143	187	15.9	954

All units mg/kg oil

ANTIMETHANOGENIC SOLID ISCR

Provect-IR® and Provect-IRM™

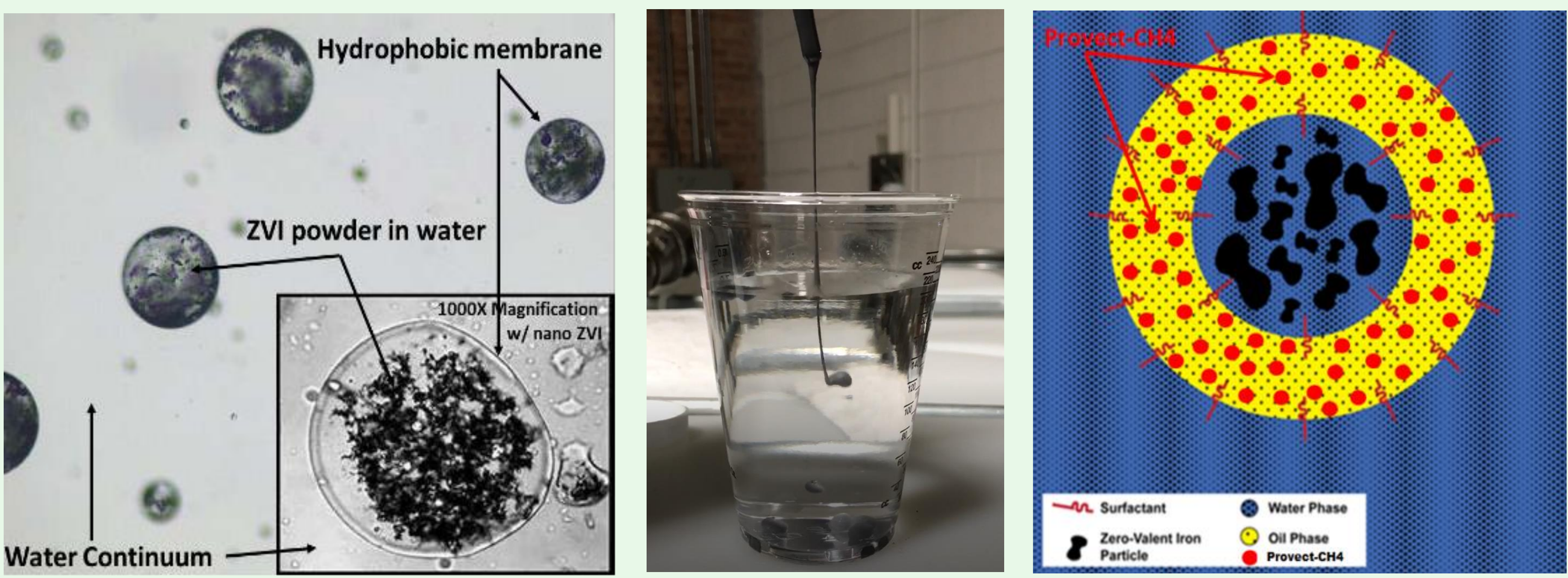


Provect-IR® Antimethanogenic *in situ* chemical reduction (ISCR) amendment is the safest, most efficient, most cost-effective product available.

- Custom formulations with optional Provect-CH₄® for methane control
- Premium ZVI from 3 to >400 micron at 15 to 85% weight basis
- Multiple hydrophilic, nutrient rich, complex organic carbon sources
- Chemical oxygen scavengers
- In situ formation (free!) of reactive iron minerals such as magnetite and precipitated iron sulfides such as Mackinawite
- Industry leading Quality Control
- Patents honored (notably 7,531,709 and 9,221,699 and others)
- Made in the USA, Brazil, Italy and Taiwan

ANTIMETHANOGENIC EZVI

Provect-EZVI CH₄™



Antimethanogenic Emulsified Zero Valent Iron (EZVI) technology is the most advanced, cost efficient product available.

- Custom formulations with optional Provect-CH₄® for methane control
- Lower viscosity formulations – maximizes distribution & contact
- pH Stabilized – optimizes emulsion stability & reactivity
- Catalyzed ZVI – enhance reactivity
- Industry leading Quality Control - emulsion structure, density, hydrophobicity
- NASA Patents honored
- Viable alternative to thermal treatment of chlorinated solvents
- Made in the USA and Brazil