Leaching of cadmium and tellurium from cadmium telluride (CdTe) thin-film solar panels under simulated landfill conditions

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MATERIALS AND METHODS SECTION

Synthetic leachate solution composition.

The columns were fed a synthetic leachate solution composed of a mixture of VFA (in mg L^{-1}): sodium acetate (CH_3COONa, 470); propionic acid (C_2H_5COOH, 120); butyric acid (C_3H_7COOH, 250); valeric acid (C_4H_9COOH, 100); and caproic acid ($C_5H_{11}COOH$, 140); representing a total of 1.5 g COD L^{-1}. The following macronutrients (in mg L^{-1}): NH_4Cl (668); $MgSO_4 \cdot 7H_2O$ (10); KH_2PO_4 (32); $CaCl_2 \cdot 2H_2O$ (10); $MgCl_2 \cdot 6H_2O$ (68); yeast extract (20), and 1 mL L^{-1} of a trace elements stock solution were also added to the synthetic leachate. The trace elements stock solution used consisted of (in mg L^{-1}): H_3BO_3 (50), $FeCl_2 \cdot 4H_2O$ (2000), $ZnCl_2$ (50), $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$ (50), $AlCl_3 \cdot 6H_2O$ (90), $CoCl_2 \cdot 6H_2O$ (2000), $NiCl_2 \cdot 6H_2O$ (50), $CuCl_2 \cdot 2H_2O$ (30), $NaSeO_3 \cdot 5H_2O$ (100), EDTA (1000), resazurin (200), and 1 mL of HCl (37% wt.)

Standardized leaching tests

Table S1 summarizes the experimental conditions used in the leaching tests. Both tests were conducted in 160 mL glass serum bottles (Wheaton, Millville, NJ, USA). The headspaces of the flasks were filled with air, in the case of the TCLP test, or N_2 gas for the WET test, as specified in the respective leaching procedures. The glass bottles were then placed vertically in a rotary apparatus (AR 112, Thumler's tumbler, Auburn, WA, USA) for agitation at 21 rpm. After incubation, the liquid phases were passed through a 0.45 μm filter (Whatman, Pittsburgh, PA, USA) and the filtrates prepared for analytical determination of Cd and Te. Negative controls (leaching solutions lacking solar panel fragments) were run in parallel. Both tests were performed in duplicate.

Table S1. Summary of the experimental conditions applied in the standardized leaching tests performed in this work.

	TCLP	**WET**
Solid to extraction fluid (w/w)	1:20	1:10
Non- encapsulated solar panel*: extraction fluid (g/g)	5.02:100.5	5.02:50.25
Extraction fluid (0.2 M)	Acetic acid	Sodium citrate
pH	4.93 ± 0.05	5.00 ± 0.05
Headspace	Ambient air	N_2
Extraction period (h)	18	48

* 25 mg of snipped thin film and 5 gr of crushed glass

Analytical methods

Total soluble Cd and Te. Liquid samples obtained from both columns were centrifuged at 12000 rpm for 10 min and the supernatants were diluted into a 2% v/v HNO_3 solution. The acidified samples were analyzed for soluble Te and Cd using an inductively coupled plasma−optical emission spectroscopy instrument (ICP-OES Optima 2100 DV, Perkin-Elmer TM, Shelton, CT, USA) at a wavelength of 228.802 for Cd and 238.578 nm for Te. The detection limits of Cd and Te were 0.1 and 10 μg L^{-1}, respectively.

Volatile fatty acid (VFA) determination. The corresponding liquid samples were centrifuged in centrifuge tubes at 12000 rpm for 10 min. Aliquots of the supernatant (1 mL) were transferred into glass microvials along with 10 μL of formic acid. The vials were then capped with aluminum seals and the concentration of the VFA mixture was then quantified by gas chromatography (7890A GC System, Agilent Technologies, Santa Clara, CA, USA) using a fused silica Stabilwax®-DA column (30 m × 530 µm × 0.25 µm, Restek, State College, PA, USA) and a flame ionization detector. The temperature of the injector port and the detector were set at 280°C. The initial temperature of the column was 100°C and it was increased to 150°C at a rate of 8°C min^{-1} to achieve proper VFA separation. Helium was used as the carrier gas (5.2 mL min^{-1}), and air and hydrogen as the flame source. The injection volume was 1 µL.

FIGURE

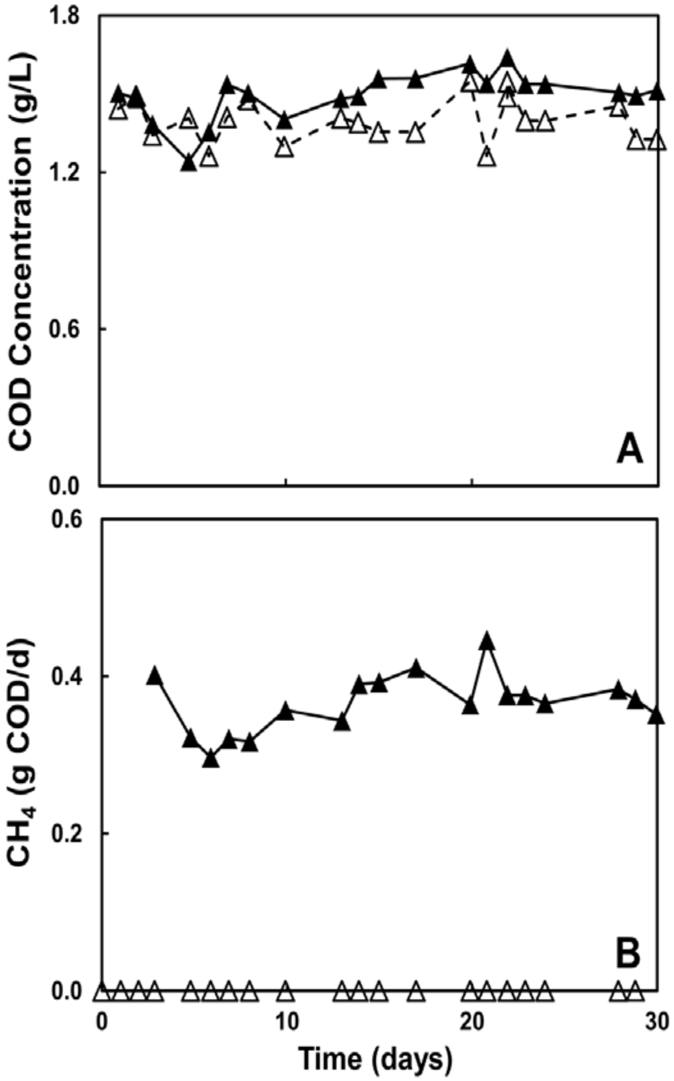

Figure S1. (**Panel A**) COD concentration in the influent (▲) and effluent (Δ) of the acidic column (pH 4.67 ± 0.06). (**Panel B**) Daily production of methane as a function of the operation time: (▲), maximum expected concentration based on the amount of COD added to the influent; (Δ), daily measured production.