Development of an Expedited Field Study Method for PCBs in Sediments and Soils Using Portable GC/MS

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Introduction

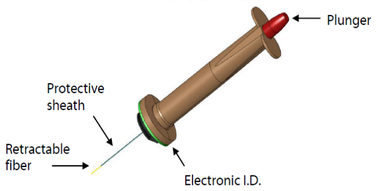
Polychlorinated biphenyls (PCBs) belong to persistent organic pollutants (POP), which are bioaccumulative and resistant to biodegradation. Gas chromatography/mass spectrometry (GC/MS) is the most commonly used technique to quantify and determine PCBs and dioxins from different matrices. Current procedures for assessing environmental PCB contamination on Department of Energy (DOE) property rely on collecting numerous surface and bore samples and sending all samples to DOE certified laboratories for analysis. This approach is extremely expensive (typically ≥ $1000/sample) and a lengthy turn-around-time (TAT) from the laboratory. Here, we develop a fast, on-site method to analyze PCBs in sediments and soils above 10 ppm using a commercial field-portable GC/MS and solid phase microextraction (SPME).

Instrument and Method

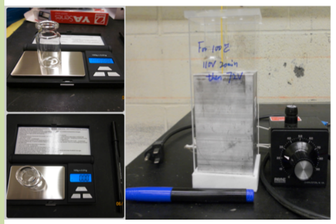
The portable TRIDION-9 GC-MS instrument (Torion Technologies, American Fork, UT, USA) is a completely stand-alone system with a disposable helium cartridge and a rechargeable battery. The entire system weighs about 13 kg (28 lb) and is 47 × 36 × 18 cm (18.5 × 14 × 7 in) in size. It has a touch screen display and the instrument is ready for injection within 3 min of switching on which are beneficial for on-site studies. The SPME fiber on the specially designed SPME device can be extended from or withdrawn into a protective metal needle by pushing the plunger on top of the holder. Commercial SPME fibers from Supelco (Bellefonte, PA, USA) can be used in this holder. A portable scale is used to measure the mass of a soil sample. A heating block with cover is used for sample extraction.

SPME-GC/MS (TRIDION-9) system

SPME device

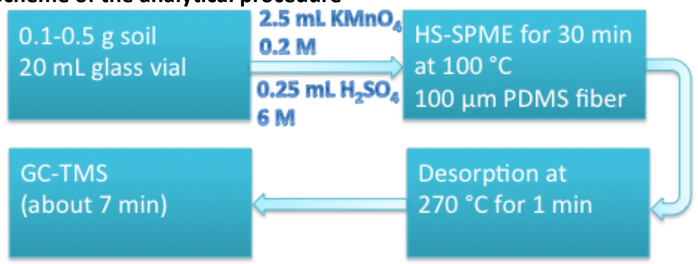


Portable scale and heating block with cover

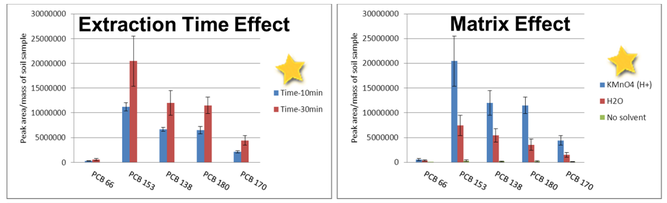


PCB congeners or Aroclor 1260 (trade name of commercial PCB product) were extracted by SPME and analyzed by portable GC/MS. PCB 66, 153, 138, 180, and 170 were chosen to investigate the extraction conditions for Aroclor 1260, a known contaminant in the region. To achieve the maximum extraction efficiency, the effects of SPME sorption time, agitation, pH, $KMnO_4$ and H_2O were investigated. Different Aroclors such as Aroclor 1254, 1016, 1248, 1232, and 1242 were tested using the same method.

Scheme of the analytical procedure



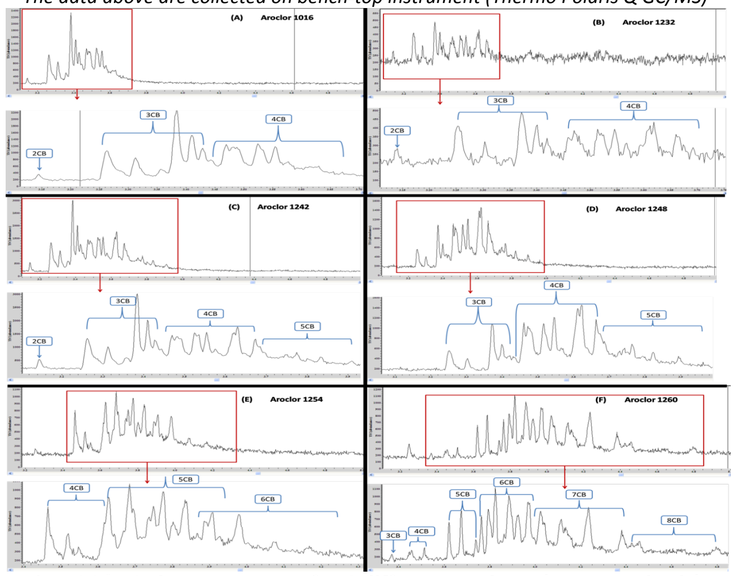
Results



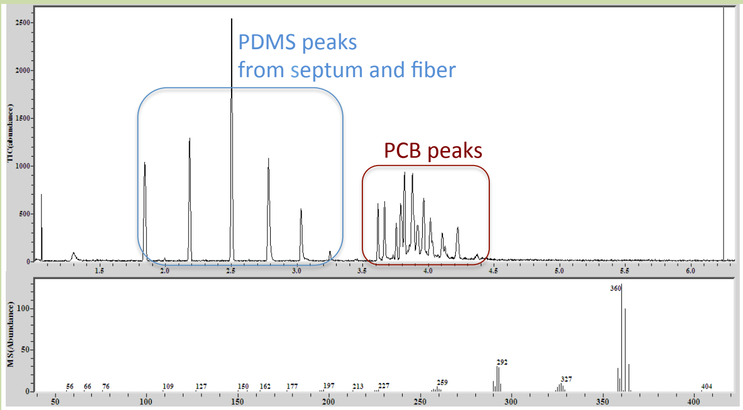
Effects of SPME sorption time, agitation, addition of $KMnO_4$ and H_2O and addition of acid and base on extraction efficiency of PCB 66, PCB 153, PCB 138, PCB 180, and PCB 170.

Paired t-test results show significant difference

** The data above are collected on bench-top instrument (Thermo Polaris Q GC/MS)*



Torion GC/MS chromatograms for 6 different Arolcors (5 µg standards)



Example of Torion GC/MS chromatogram (top) and mass spectrum (bottom) for 10 ppm Aroclor simulated soil sample

Conclusion

1. Longer extraction times, as well as the addition of water and $KMnO_4$ can improve the extraction efficiency. No significant differences were found between agitation and no-agitation groups.
2. The total analysis time of the method was less than 45 min. The detection limit was 10 ppm for Arochlor 1260. Small amounts of soil samples were required and no organic solvents were required.
3. The portable instrument has the potential for on-site identification and even quantification of Aroclor contaminants in soil. The method can be modified for other priority pollutants, such as trichloroethylene (TCE).

Future Work

- ✓ Improvement of sensitivity to determine the ppb range of Aroclor in soil samples.
- ✓ Analysis of multiple Aroclors in soil
- ✓ Method validation
- ✓ Field analysis of PCBs in soil samples

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