Rapid In-Field Analysis of Crude Oil Contamination in Soil using a Handheld Infrared Device

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Background

Current industry practice for analyzing crude oil contamination in soil involves sending soil samples to an off-site laboratory for the analysis of total petroleum hydrocarbons (TPH), with standard turnaround times of 5-10 days. This is a relatively costly, time-consuming process and limits the amount of data points that can be collected due to budgetary considerations.

A novel handheld infrared device (marketed by Ziltek as RemScan™) can be used to measure crude oil contamination infield in soil in less than 20 seconds, with similar performance to gas chromatography-based laboratory assays. The infrared device uses diffuse reflectance, where a mid-infrared beam hits the soil surface and reflects back to a detector, generating a 20-second measurement. No solvent extraction or hazardous chemicals are required – it is a direct measurement.

This disruptive technology (US Patents 8759775, 8914312) is being utilized by the oil industry worldwide to accelerate site closure, cut laboratory analysis costs and to collect more data points for better sampling statistics and increased confidence in decision making.

Figure 1: RemScan™; a handheld infrared device for rapid measurement of TPH in soil.

Methods

The methodology of the former USEPA Environmental Technology Verification (ETV) Program was used to compare laboratory assay data for TPH in soil with measurements made using the handheld infrared device. The validation study was conducted on a wide range of soil types and petroleum contaminants from different sites around the world including North America, Europe, Middle East, South East Asia (tropical), Africa (tropical), and Australia.

For each site, around 50-100 soil samples were air-dried, screened and scanned with the infrared device and then sent to an accredited laboratory for analysis of TPH (C_{10}-C_{36}) using USEPA Method 3570:8015C. The resulting data was used to calibrate the infrared device for each respective site (using Partial Least Squares regression analysis), and the device was then used to predict the TPH (C_{10} to C_{36}) concentrations in a number of blind validation samples from that site. A statistical comparison was made between the infrared device measurements and laboratory assay results including accuracy and repeatability.

Results and Discussion

Table 1: A statistical comparison of laboratory assay data (TPH) and infrared device measurements for a range of different soil types containing various petroleum contaminants.

Site	0-3,000 mg/kg TPH Range				0-100,000 mg/kg TPH Range		Blind Validation? (Yes/No)
	RMSECV[b] (mg/kg TPH)	Correlation Coefficient (R^2)	Detection Limit[c] (mg/kg TPH)	Repeatability (%)	RMSD[d] (mg/kg TPH)	No of Calibration Samples	
1[a]	124	0.97	66	1.8	822*	60	Yes
2[a]	88	0.96	64	3.3	n.m.	60	Yes
3	123	0.99	65	2.6	1,225	50	Yes
4	137	0.98	77	2.3	1,293	48	Yes
5	190	0.98	n.m.	<3	1,091	43	Yes
6	170	0.92	n.m.	<3	2,984	111	Yes
7	376	0.99	n.m.	<3	2,888	183	Yes
8	78	0.99	<78	<3	1,271	36	Yes

Footnotes:
[a] Data validated by Battelle using the methodology of the former USEPA Environmental Technology Verification (ETV) Program.
[b] RMSECV = Root Mean Square Error of Cross Validation
[c] Detection limit calculated at 1 standard deviation
[d] RMSD = Root Mean Square Deviation
* RMSD calculated between 5,000 - 10,000 mg/kg TPH
n.m. Not measured

Table 2: The range of applications for which RemScan has been used.

Current User Regions	Petroleum Contaminants	Applications	Soil Types
• North America • Europe • Middle East • South East Asia (tropical) • Africa (tropical) • Australia	• Crude oil (light, heavy) • Diesel • Transformer oil • Mineral oil • Jet fuel (non-volatiles) • Gasoline (non-volatiles)	• Spill delineation • Remediation validation • Site characterization • Bioremediation monitoring	• Sandy (coarse, fine) • Loam • Clay • Heavy clay • Swampy peat

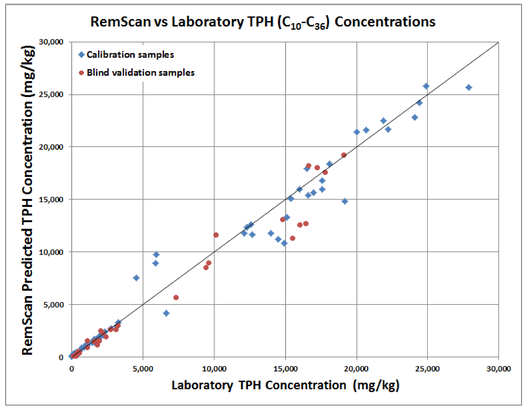

Figure 2: A comparison of laboratory assays with infrared device measurements for soils from Site 1 showing calibration samples (blue) and blind validation samples (red). All data was independently verified by Battelle.

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Conclusion

The RemScan™ handheld infrared device can be used as a powerful field screening tool for measuring TPH in soil to complement gas chromatography-based laboratory analysis.