An improved proximal sensing capabilities in low background oil contamination detection in soils

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Supervisors

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About me

- Degree – Geology (ABU Zaria)
- Work – 3 years as a field geologist (Geobla Exploration Kaduna)
- MSc – Petroleum geology (ABU Zaria)
- MSc – Environmental Geology and Contamination (UoP)
- PhD - Environmental Geosciences (UoP)
- Part-time Teaching Assistant (UoP)
- Part-time Research Assistant, Dr-SUIT project (UKRI-funded) (UoP)
- **In the job market**

Outline

- Introduction
- Rationale
- objectives
- Experiments
- Research output
- Application
- Conclusion

Why soil?

- Agriculture
- Limited studies
- Estimated area of bare soil is 35 x 10^6 km^2 (Sterling and Ducharne, 2008)
- Exploration, production, refining and transportation sites
- Potential oil spill sites
- Arid regions

How much oil is acceptable?

- **Acceptable limit;**
- ≤100mg/kg ~ 0.1% of TPH (US, UK)
- Most techniques cannot detect very low oil concentrations.

- **Current geophysical techniques (e.g. Resistivity, GPR do not provide the needed answers)**
- **GC may be costly and time consuming**
- **Vis-NIR Spectroscopy may be an alternative**

My research

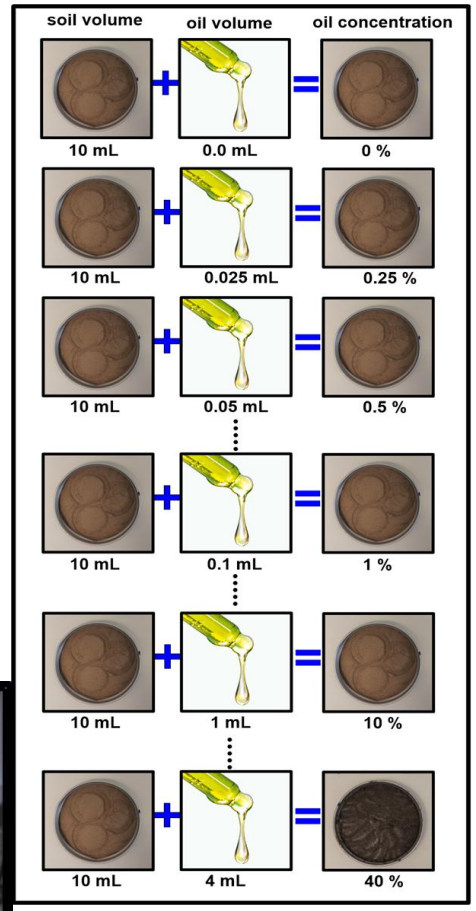
- To develop cost-effective and rapid method to estimate low background oil concentrations on bare soil
  Other objs;
  - Enhanced detection and quantification (up to 40%)
  - In-situ monitoring
  - Soil-oil interaction (sorption)

Soil-oil experiment

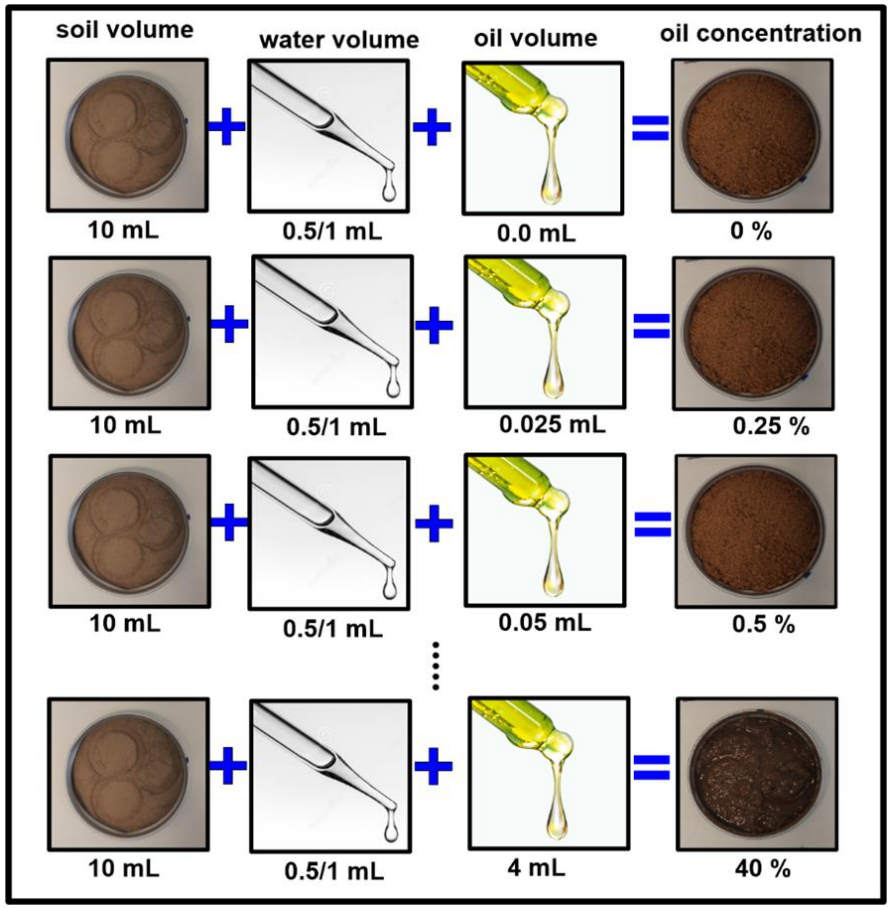
- Dry: 0-40% oil (26 soils)
- 5% moisture 0-40% oil (8 soils)
- 10% moisture 0-40% oil (8 soils)
- Breckland crude oil substitute

- All tests triplicate

- 126 full tests using ASD LabSpec4 Spectrometre (350 -2500 nm)

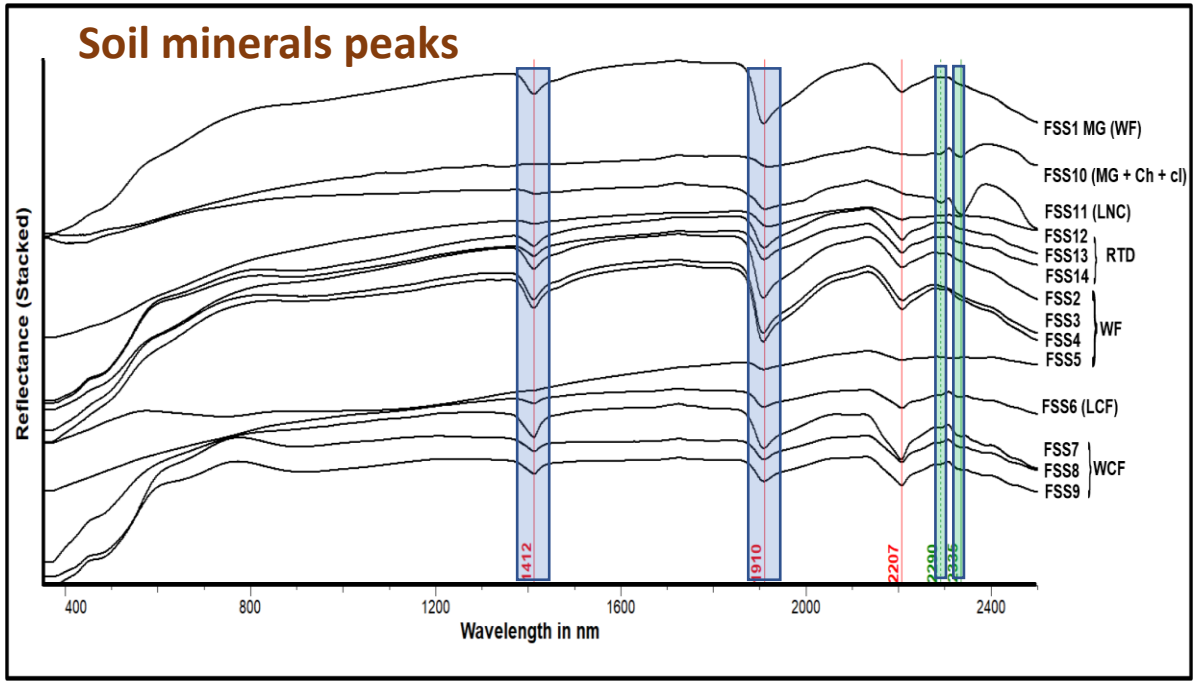


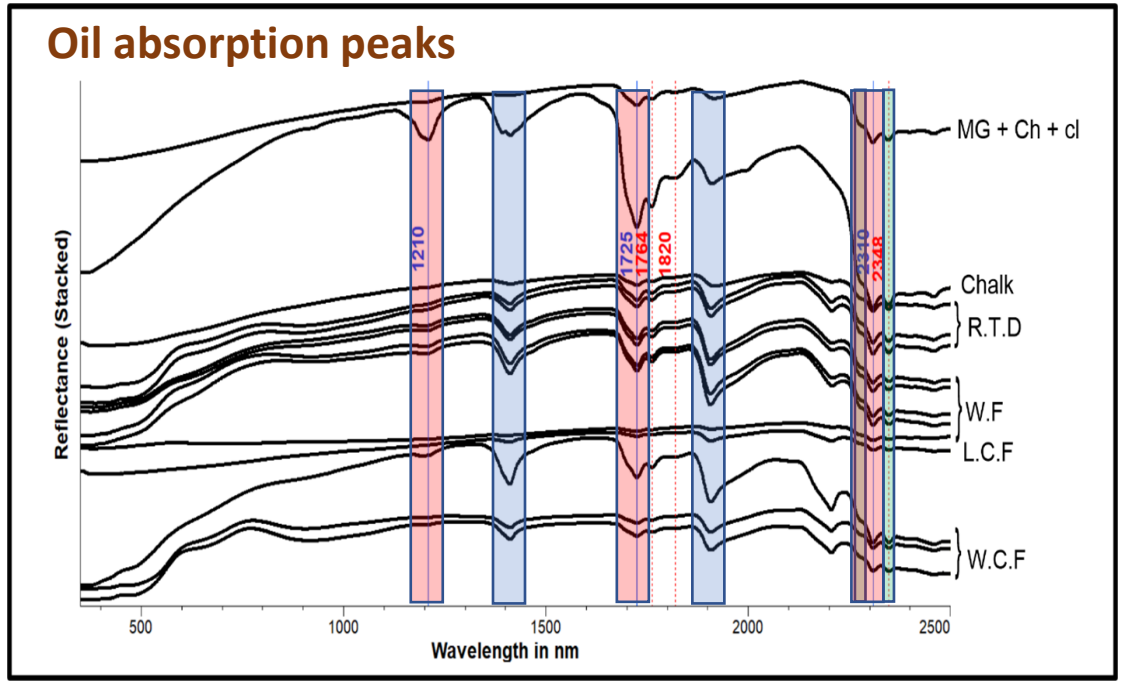
Dry



Wet

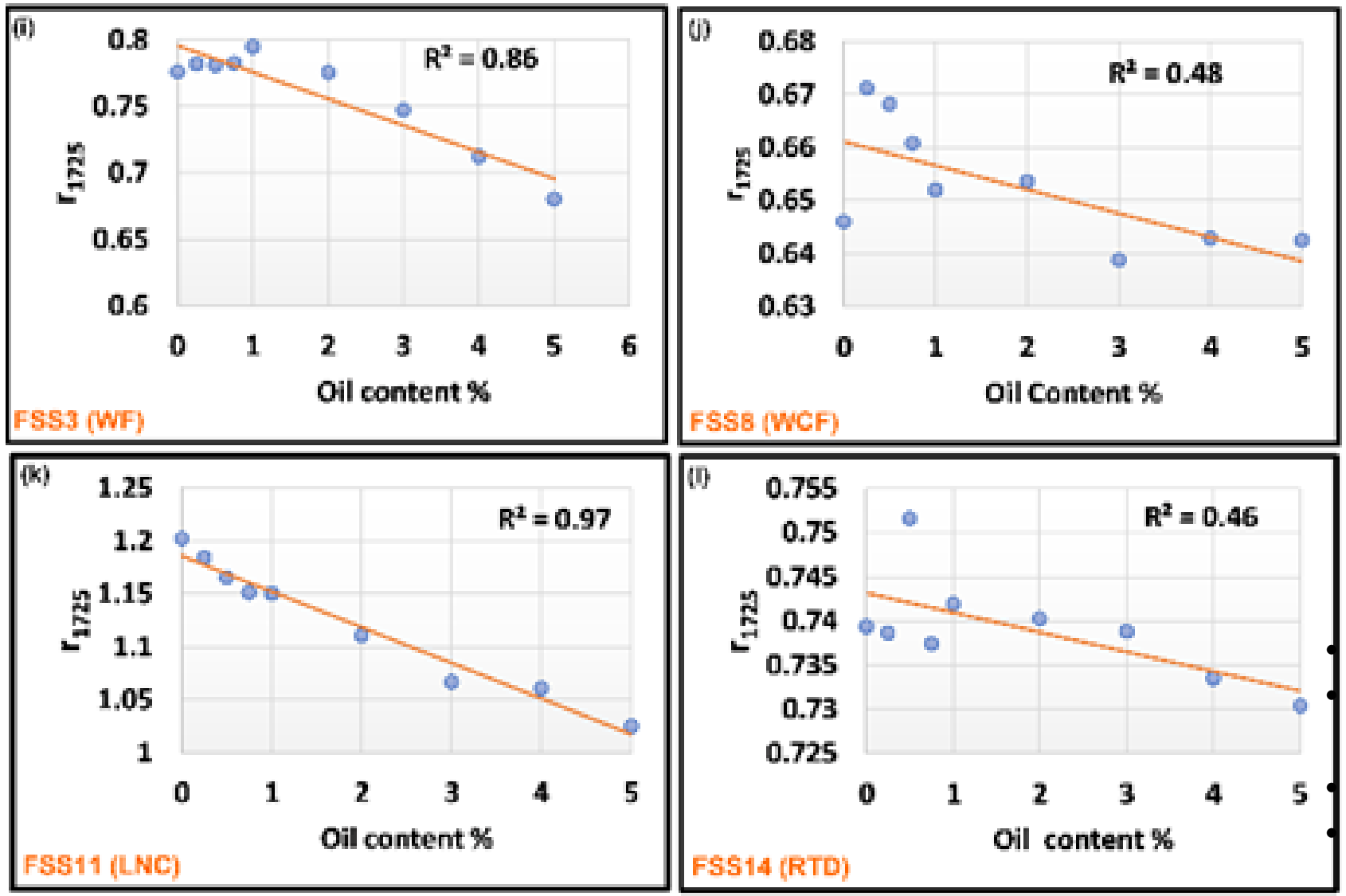
Research output: soil & oil signatures





- Soil absorption peaks (clay=1412, 1910 nm…, calcite=2290, 2335 nm)
- Oil absorption peaks (**1210**, 1720,**1725**, 1764, **2310** nm).
- 1725nm mostly used in PLSR Models in literature for oil prediction but not an efficient estimator

Low background estimation using 1725nm



- **WF= Wittering Formation**
- **WCF= Weald Clay Formation**
- **LNC= Lewes Nodular Chalk**
- **RTD= River Terrace Deposit**

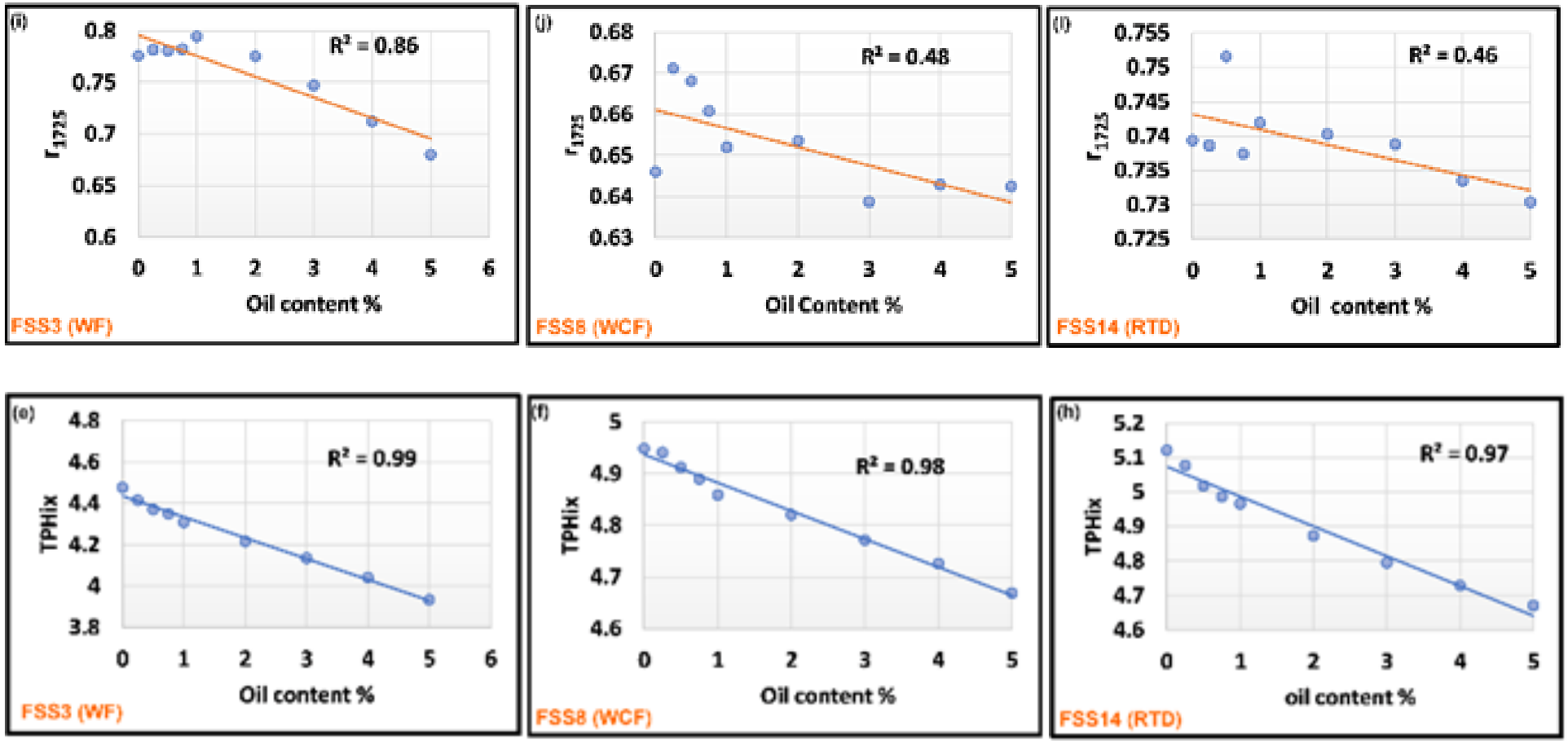
Research output: New Index to estimate oil content

TPH Index

- Derived from key physical characteristics
- Combines 3 key absorption features
- Less sensitive to composition & moisture content?

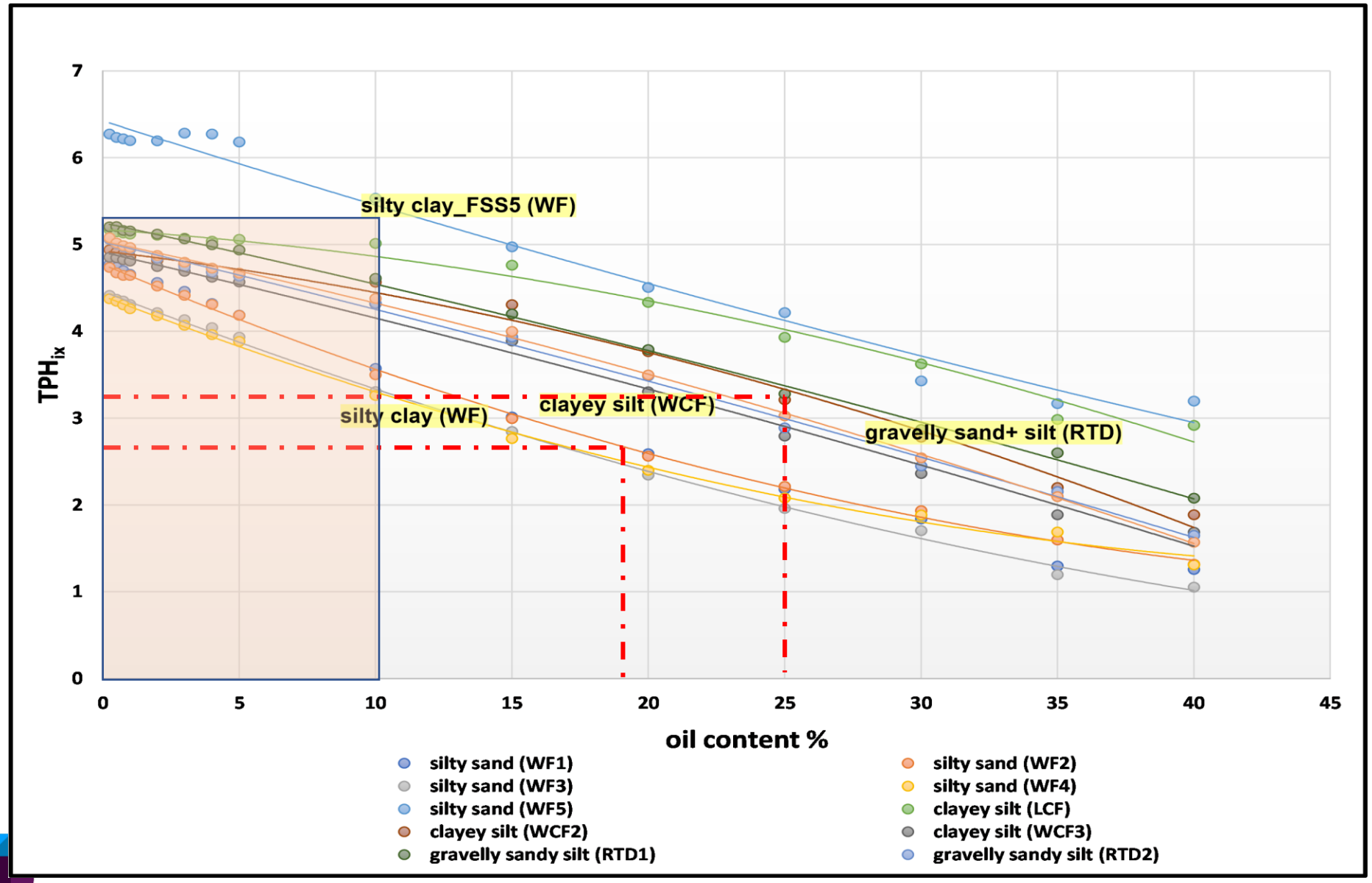
$$TPH_{ix} = \frac{r_{2310}}{r_{1725} + r_{1210}} * 10$$

r_{1725nm} vs TPH_{ix}



WF= Wittering Formation, WCF= Weald Clay Formation, RTD= River Terrace Deposit

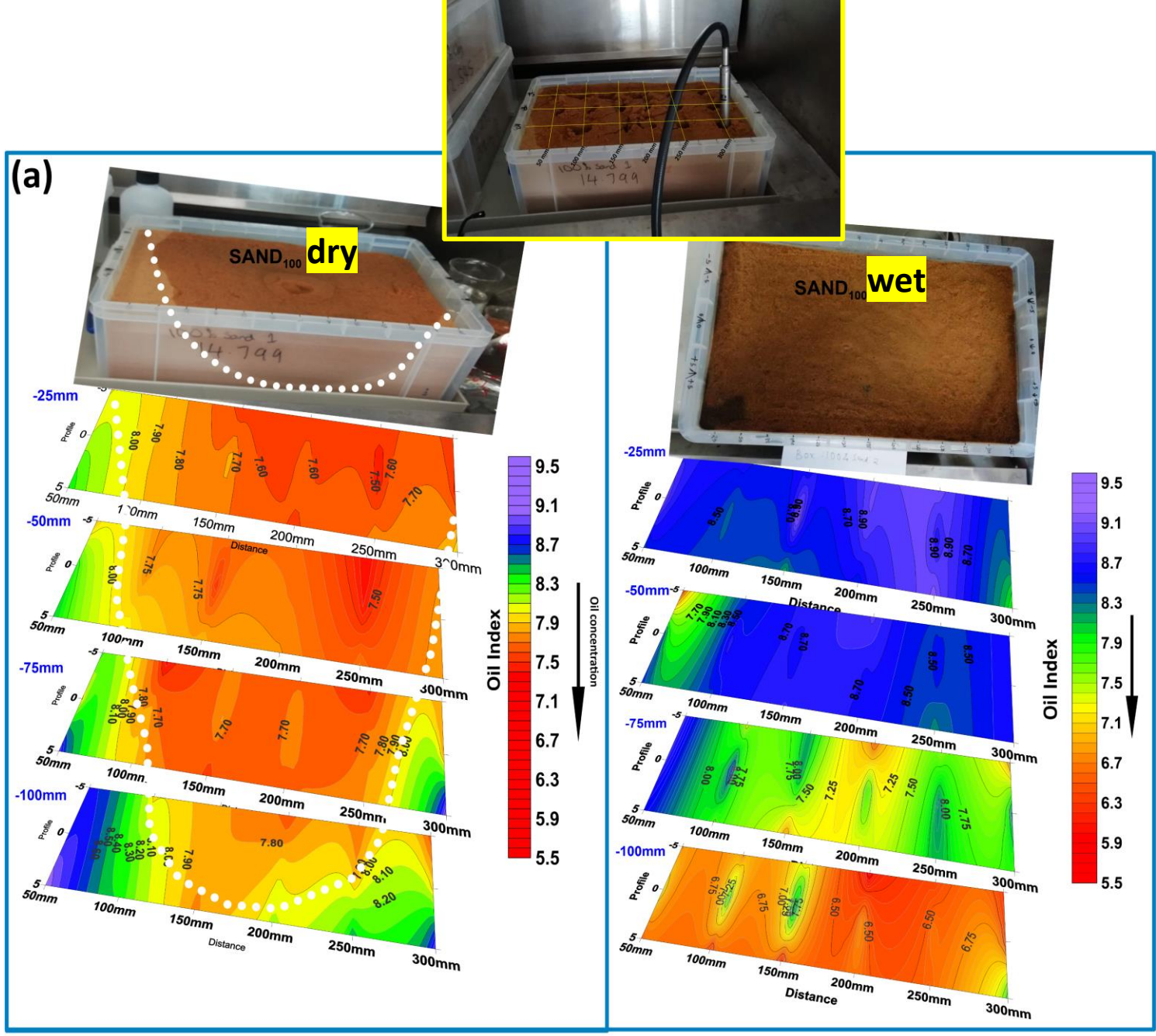
TPH_{ix}- Oil estimation



- Enhanced and rapid detection
- Excellent at low oil content compared to R_{1725}
- TPH_{ix} values can quantify oil concentration on bare soils
- QC remediation
- Finer details may be required (e.g. mineralogy & OM content)

In-situ Monitoring

- **$SAND_{100}$ (sand)**
- TPH_{ix} values plotted at 25mm depth intervals up to 100mm
- Funnel-shape movement in dry $SAND_{100}$ but laterally in wet $SAND_{100}$
- TPH_{ix} values indicated contamination levels in dry and wet conditions
- TPH_{ix} decreases with depth for wet soil giving an indication of accumulation



Technical applications

- Considered for rapid in-situ field applications
- Better alternative for low background oil detection
- Applicable in different soil types and moisture conditions

Conclusion

- VNIRS offers an option for low background concentration estimation.
  - 100mg/kg acceptable limit can be met
- TPH_{ix} applicable to different soil types
- Potential application in oil prospecting as well
- Method developed is rapid and cost-effective and can improve oil spill response protocols in soil substrates

Thank you for listening!

Appreciation

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