Connections Between Chemistry and Hyperspectral Reflectance of Wildfire Effected Soils Toward Satellite Remote Sensing of Soil Water Repellency

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Introduction

- Wildfire activity and intensity in the western U.S. have greatly increased, mainly due to a warming climate, population growth, land use changes, and fuel accumulation [1].
- Forest fires modify physical and chemical soil properties and generally cause Fire-Induced Soil Hydrophobicity (FISH), which reduces water infiltration into the soil and accelerates runoff from postfire precipitation events [2].
- We have sampled surface soils from each of the recent California, USA megafires: the Dixie, Beckwourth Complex, and Caldor fires (Table 1) and we studied the optical, chemical, and hydrological properties of unburned and burned soil samples.
- We aim to find correlations between the optical, chemical, and hydrological measurements, as needed for using hyperspectral remote sensing to understand, predict, and mitigate postfire, watershed-wide hydrological responses including flooding, landslides, and deterioration of water quality [3].

Materials and Methods

Table 1. Description of the three megafires

Fire name	Start date-End date	Burned area (km^2)	Sample type	Sampling dates	Method used for analysis	GPS coordinates of sampling sites
Dixie	13-July-2021 – 25-Oct.-2021	3898	Ash, burned, and unburned soil	5-Oct.-2021 30-Oct.-2022 20-June-2023	ASD FieldSpec3 FTIR	39°58'41.9"N 120°21'24.8"W
Beckwourth Complex	4-July-2021– 22-Sept.-2021	428	Ash, burned, and unburned soil	5-Oct.-2021 30-Oct.-2022 20-June-2023	ASD FieldSpec3	39°53'21.1"N 120°12'02.9"W
Caldor	14-Aug.-2021 – 21-Oct.-2021	898	Ash, burned, and unburned soil	21-Oct.-2021 19-Nov.-2022 12-July-2023	ASD FieldSpec3	38°50'37.0"N 120°01'59.8"W

Figure 1. Soil samples collected shortly after the 2021 Dixie fire: ash, burned soil and unburned soil (from left to right).

Methods

WDPT and goniometer measurements

Figure 2. Water drop penetration time (WDPT) measurements in the field, shortly after the Dixie fire was contained, showing water drops siting on burned soil.

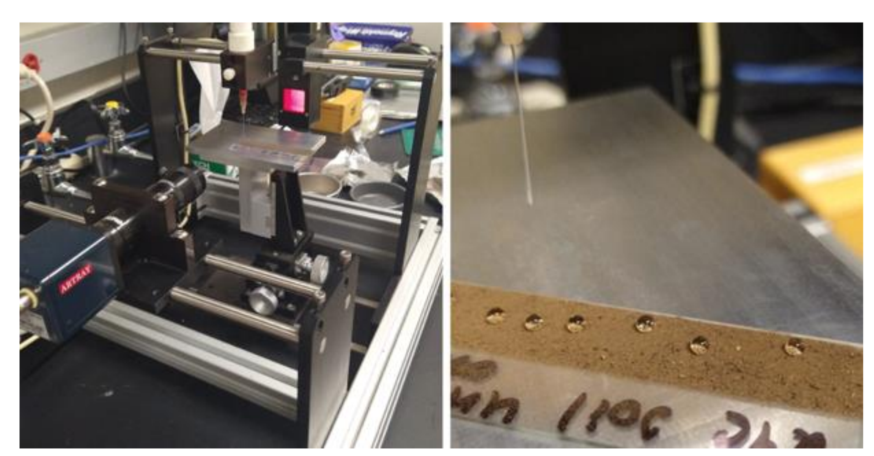

Figure 3. Goniometer instrument (left) used for apparent contact angle measurements (ACA) of soil samples loaded on a microscope slide (right).

ASD FieldSpec3 measurements

Figure 4. ASD FieldSpec3 set up for acquiring reflectance spectra on DRI rooftop.

FTIR measurements

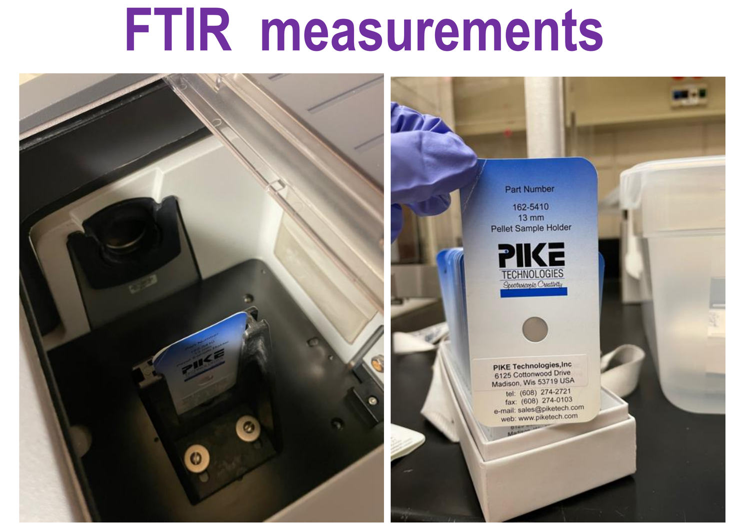

Figure 5. Preparation of pellets of 0.003 g of 0-month, 1-year, and 1.5-year Dixie ash per 0.2 g KBr.

Results

Reflectance Data

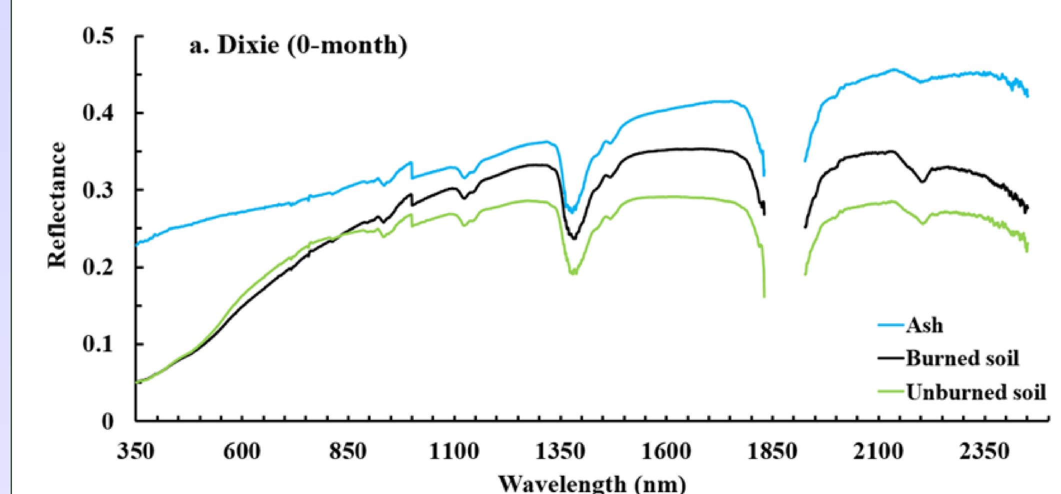

Figure 6. Reflectance spectra of 2021 ash, burned soil, and unburned soil samples collected 0-month after the Dixie fire.

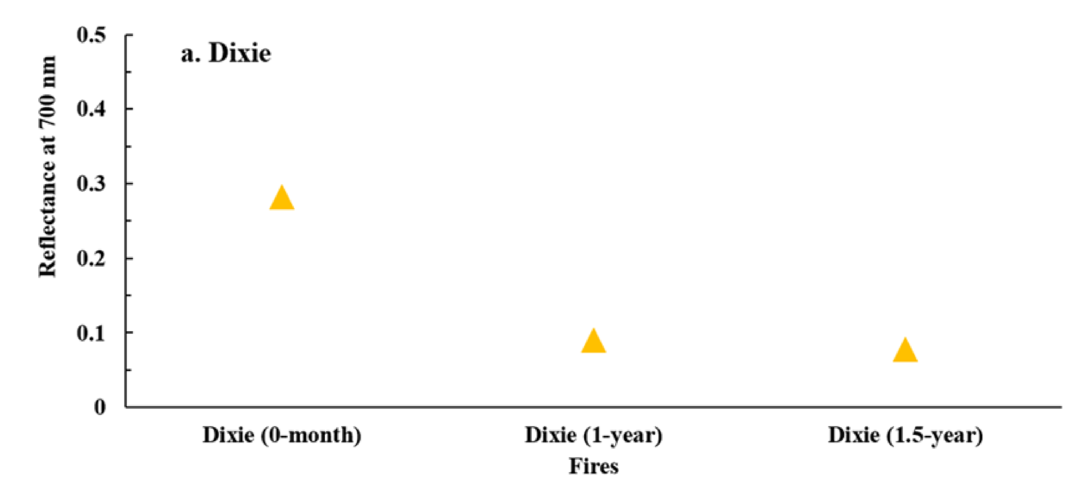

Figure 7. Reflectance at 700 nm of ash samples collected fresh, 1-year, and 1.5-year after the Dixie fire.

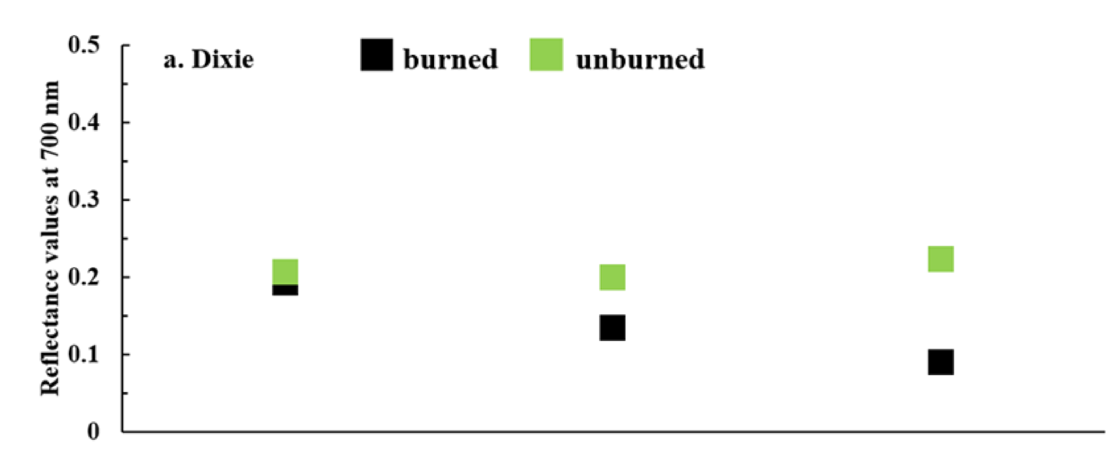

Figure 8. Plots of 700-nm reflectances for burned soil, and unburned soil samples collected fresh, 1-year, and 1.5-year after the Dixie fire.

FTIR Data

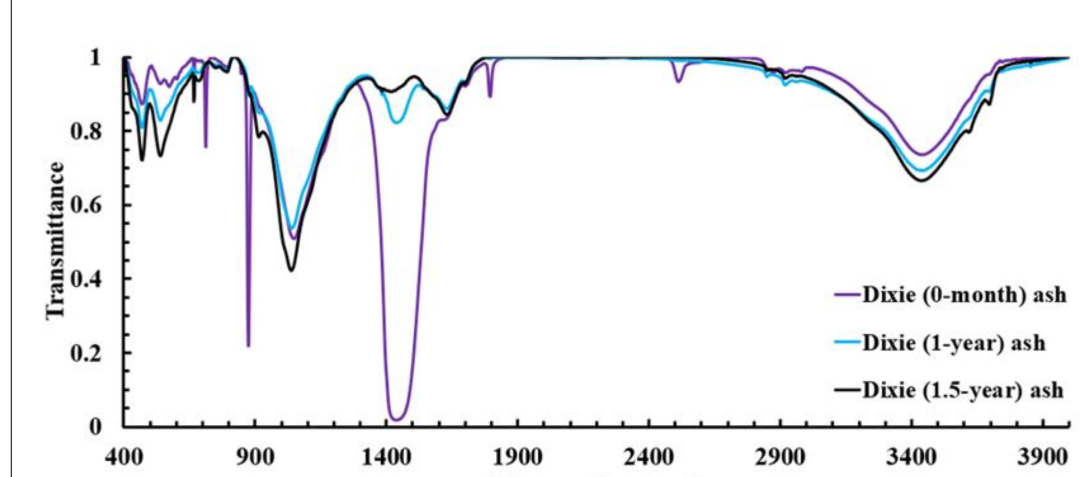

Figure 9. FTIR transmission spectra for ash samples prepared with KBr pellets for Dixie fire ash samples collected in 2021 (0-month), 2022 (1-year), and 2023 (1.5-year).

Conclusions

- Higher visible reflectance for unburned soils than for burned soils, including for samples collected 1 and 1.5 year after the fires compared to samples collected immediately after the fire for all three megafires.
- No clear trend was observed in the change of reflectance for unburned and burned soil over time.
- In case of ash samples, for all fires a distinct decrease in reflectance was observed 1.5 year after the fires.
- A very noticeable reduction (over 90 % of area) of the carbonate signal (near 1440.6 cm^{-1}) explains the reduction in reflectance for 1-year and 1.5-year ash samples from all fires

Future Research

- Comparison of results from laboratory and wildland burns.
- Comparison of FTIR data for soils near different plants in the sagebrush ecosystem and investigating correlations between their reflectance spectra, soil chemistry, and ACA.

References

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