Effect of Kerosene Contamination on the Sand-Kaolinite Soil (SC) Electrical Properties

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1. Abstract

In this study the effects of kerosene on the Sandy soil with 10% Kaolinite was studied using 2.5% - 7.5% kerosene. Also, an electrical method was used to characterize the soil and identify the critical electrical property to monitor. Impedance-frequency response of the soil increased with the addition of kerosene. With the addition of kerosene from 2.5% to 7.5%, soil sample resistivity and resistance increased by 184% and 148% respectively.

2. Introduction

The increasing usage of petroleum products for energy needs has increased the oil contamination in water and soil (Rajaie, et al. 2011). Oil contamination occurs during the extraction, processing, and transportation of oil. Oil spills also contribute to the contamination of water and soil. In the accident of Gulf of Mexico in 2010, 4 million barrels oil spilled in the sea (Deepwater Horizon – BP Gulf of Mexico Oil Spill 2022). Several studies have been conducted to study the impact of oil contamination in the mechanical properties of the soil (Vipulanandan and Elesvwarapu 2008; Zomorodian, et al. 2017). The effects of oil contamination on the soil strength, index properties, compaction and resistivity were summarized in Table 1. All the properties were negatively impacted with oil contamination. From Table 1, soil resistivity is reduced with oil contamination, thus soil resistivity is sensitive to oil contamination. Thus, electrical properties can be used as an indicator to study the effect of contamination in soil.

3. Objective

The objective of this study was to investigate the effect of kerosene on the electrical properties of Sandy soil with 10% Kaolinite.

4 Materials and Methods

The kerosene was added to the soil mixture (10% Kaolin and 90% Sand) in 2.5%, 5% and 7.5% (based on mass of dry soil). To simulate natural moisture content of 5%, water was added. The cylindrical specimens (50 mm diameter *100 mm height) were prepared and compacted using dynamic load of 770g. Specimen configuration is shown in Figure 1.

The resistivity of the soil was measured using a soil resistivity probe. The impedance spectroscopy was measured by two probe method, using LCR meter in 20Hz- 300kHz frequency range.

Table 1. Effects of Oil Contamination on the Soil Properties

Reference	USCS Soil type	Type of oil	% of Contamination of oil based on the dry soil weight)	Property studied	Change of contaminated soil property compared to the original soil	Remarks
Liu, et al., (2014)	Kaolinite (CL)	Diesel	4-20%	Resistivity	42-56% reduction	1. Two electrode method 2. AC current 3. contaminated soil monitored for 210 days
Delaney, et al., (2001)	Hanover silt	Kerosene	2-15%	Resistivity	10-20 % reduction	1. DC, Wenner method 2. Four Probe method
Vipulanandan and Elesvwarapu, (2008)	80% Sand 20% Kaolinite clay (CL-ML)	Kerosene	2.5-7.5%	Liquid limit, plastic limit, MDD, OMC	LL increased 75% Plasticity index increased 60% MDD decreased by 6% OMC increased by 85%	1. 2-5% Organic Matter added
Zomorodian, et al., (2017)	Sandy lean clay (CL)	Kerosene	2-12%	Unconfined compression strength	Strength reduction upto 61%	1. 1% Nanoclay, 1.5% Nanosilica optimum to improve strength
Remarks	Sand, clay silt soil	Kerosene, diesel used	2-20%	Resistivity, Index properties, compaction and unconfined compressive strength	Mechanical properties of the soil adversely impacted	1. D/C, A/C methods 2. Two probe, 4 probe methods

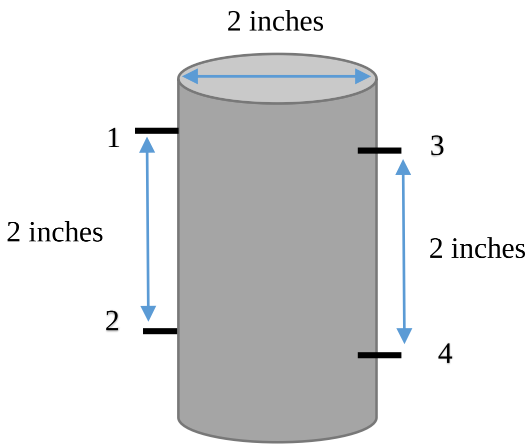

Figure 1. Testing specimen configuration

5 Results and Discussion

5.1 Characterization of added soil samples.

Impedance plot of 0, 2.5 ,5 and 7.5% kerosene contamination is shown in Figure 2. The impedance of the soil was influenced by the contamination of kerosene. Contamination of the soil has increased the impedance of the soil.

From the impedance curve the sample, it follows case -2 of Vipulanandhan Impedance Model. The resistance at 300k Hz was measured as the bulk resistance of the sample.

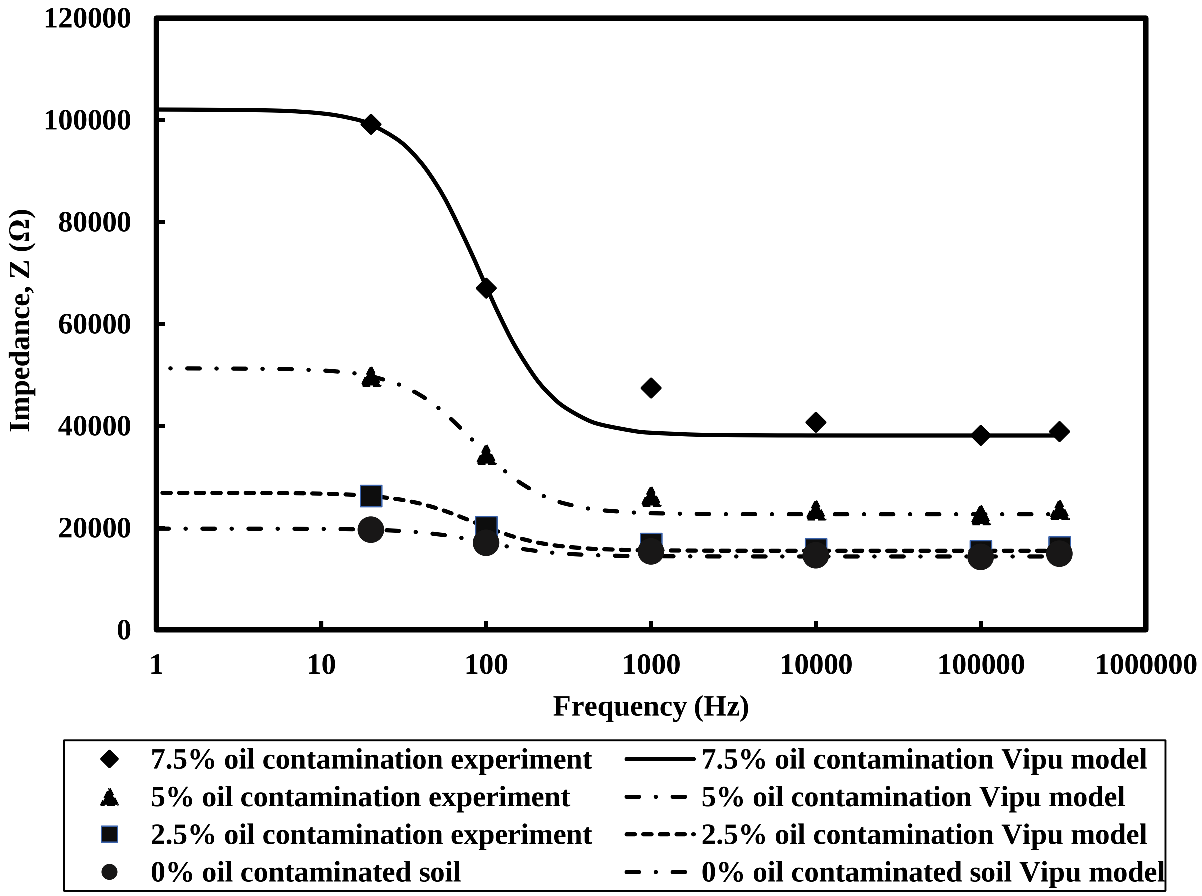

Figure 2. Impedance plot of 0%-7.5% kerosene added soil.

5.2 Monitoring of Vertical Resistivity and Resistance

The vertical resistivity and resistance value of kerosene added soil samples (with the constant density of the soil -1.91g/cm^3) are shown in Figure 3. Addition of kerosene to the soil has increased resistivity and the bulk resistance of the soil. The initial resistivity and bulk resistance of the 2.5% contaminated soil was 115 Ohm-m and 12469 Ohm. Increasing the contamination from 2.5% to 7.5% has increased the resistivity and resistance by 184.3% and 148.4% respectively.

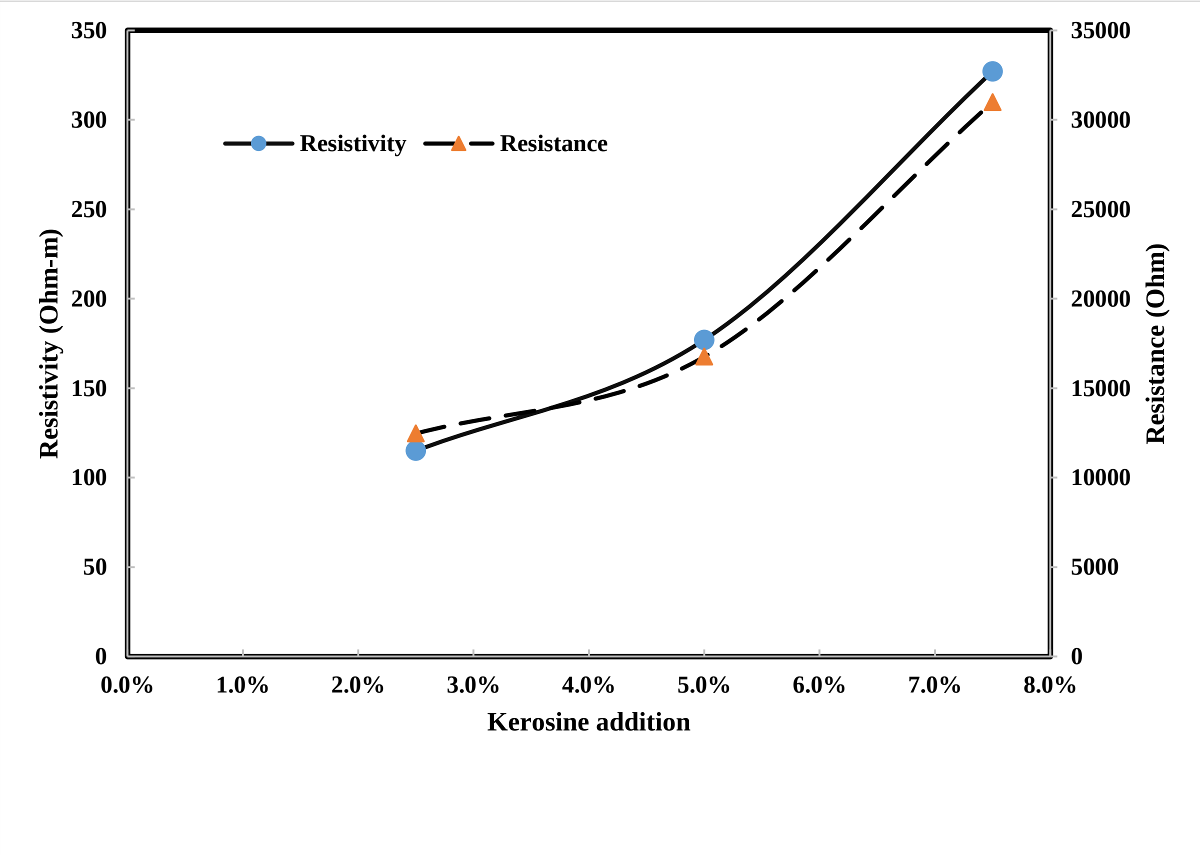

Figure 3. Vertical resistivity and resistance of soil with kerosene addition.

6. Conclusions

Based on the experimental study and modelling following conclusions are advanced:

1. Kerosene added soil sample follows Case 2 of Vipulanandan Impedance model.
2. Impedance values shift up with the kerosene contamination in the soil.
3. The vertical resistivity and resistance values of the soil, increased by 184.3% and 148.4% respectively by increasing the contamination from 2.5% to 7.5%,

7. Acknowledgement

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