Effect of Lead Nitrate contamination on the Kaolinite and Sand Soil Electrical Properties

K. Tharmakulasingham, and C. Vipulanandan, Ph.D., P.E.

Texas Hurricane Center for Innovative Technology (THC-IT)
Department of Civil and Environmental Engineering
University of Houston, Houston, Texas 77204-4003
E-mail: ktharmakulasingham@uh.edu, cvipulanandan@uh.edu Phone: (713) 743-4278

1. Abstract

In this study the effects of lead nitrate solution on the 10% Kaolinite - 90% Sand mixture soil was studied using 1% lead nitrate solution. Also, electrical methods to characterize the soil was investigated. With the addition of lead nitrate to the soil sample the resistivity and resistance were reduced. The vertical resistivity and resistance values of lead nitrate samples are lesser than water added sample reference samples.

2. Introduction

Heavy metal can pollute the soil through wastewater from various industries, agriculture, and military activities. Very limited studies have been conducted to investigate the effect of heavy metals on the geological parameters (Nasb & Keykha, 2020). The previous studies on lead nitrate contamination and the resultant geotechnical parameters changes are summarized in Table 1. Changes in pH, permeability, maximum dry density, optimum moisture content, specific gravity unconfined compressive strength, Cohesion and angle of friction were studied. From the Table 1, soil resistivity is sensitive to lead nitrate contaminate. Thus, soil resistivity can be used as an indicator to study the effect of contamination in soil.

Table 1: Geotechnical properties change with addition of lead nitrate

USCS Soil type	Range of lead nitrate solution used in the study	Geotechnical property studied	Change of contaminated soil property compared to the original	Reference
CH	1-3%	Permeability	Decreased by 19.3% to 42.2%	(Karkush & Ali, 2020)
		Maximum dry density	Increased by 2.5% - 4.9%	
		Optimum moisture content	Decreased by 14.4%-21.3%	
		Specific gravity	Increased by 1.5% -3.3%	
15% Kaolinite (CL) and 85% Sand mix	2.4%-4.8%	pH	Deceased by 7% and 10%	(Nasb & Keykha, 2020)
		Cohesion and angle of friction	Increased by 3%-15% and decreased by 8-17%	
40% Kaolinite (CL) and 60% Sand mix	2.4%-4.8%	Unconfined compressive strength	Decreased by 12.5-18%	

		Resistivity	Decreased by 15%-20%	
15% Bentonite (CH) mix 85% Sand mix	2.4%-4.8%	pH	Deceased by 3.5% and 7%	
		Cohesion and angle of friction	Decreased by 12-15 and increased by 15-21%	
40% Bentonite (CH) mix 60% Sand mix	2.4%-4.8%	Resistivity	Decreased by 18%-27%	

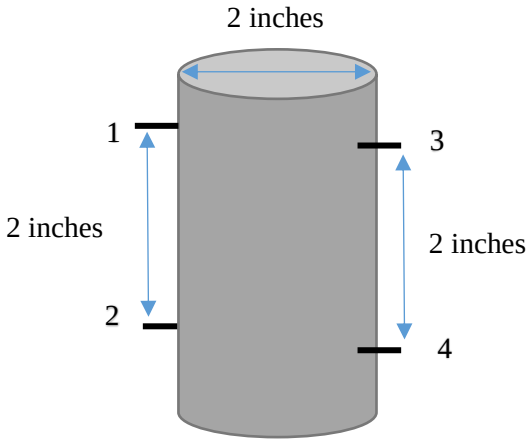

Figure 1 Testing specimen configuration

3. Objective

The objective is to study the effect of lead nitrate in the Electrical properties 10% Kaolinite and 90% Sand soil mixture.

4 Materials and Methods

Lead nitrate was added in water in 0.25%, 0.5%, 0.75% and 1%. Resistivity, Oxygen Reduction Potential (ORP) and pH was measured. 1% Lead Nitrate (6250ppm) solution was prepared. The solution was added to soil mixture (10% Kaolin and 90% Sand) in 5%, 10% and 15% (based on mass of dry soil). Reference sample was made by adding 5%, 10% and 15% water to the mixed soil.

The cylindrical specimens (50 mm dia.*100 mm height) were prepared and compacted using dynamic load of 770g. Specimen configuration is shown in Figure 1.

5 Results and Discussion

5.1 Effect of lead nitrate in Water

The pH and resistivity change with addition of lead nitrate is given in Figure 2. With the addition of lead nitrate, the pH values and resistivity values were reduced. ORP value did not change with addition of lead nitrate in water solution. From literature the pH reduction with the addition of lead nitrate is due to the cation exchange process and the release of H+ ions (Nasab and Keykha ,2020).

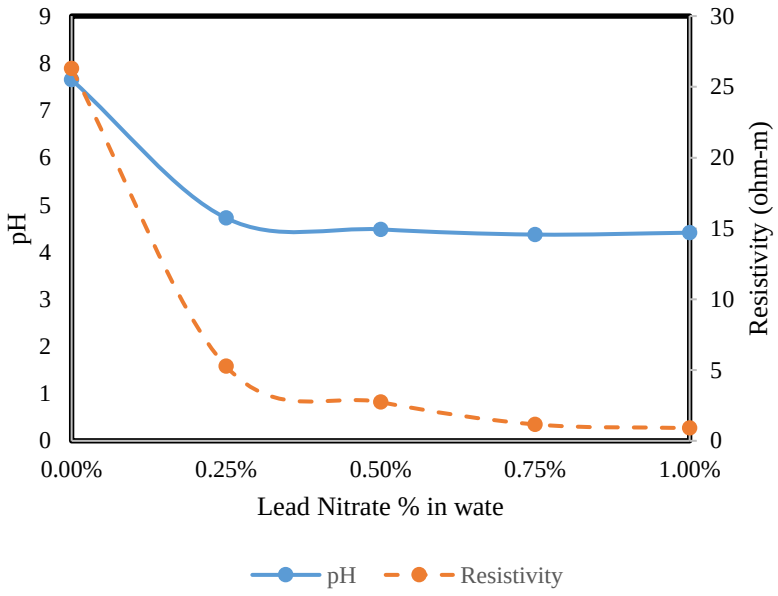

Figure 2 pH and resistivity change with addition of Lead Nitrate in water

5.2 Characterization of Lead Nitrate solution and Lead Nitrate Solution added soil samples

Impedance plot of 1% lead nitrate solution is shown in Figure 3. This behavior shown by lead nitrate solution signifies that the impedance of the solution is mostly influenced by the resistance of the solution Hence, from the impedance curve the sample, it follows case -2 of Vipulanandhan Impedance Model.

Impedance plot of 15% lead nitrate solution added soil is shown in Figure 4. From the figure lead nitrate solution added soil sample follows case 2 of Vipulanandhan Impedance Model. The resistance at 300k Hz was measured as the bulk resistance of the sample.

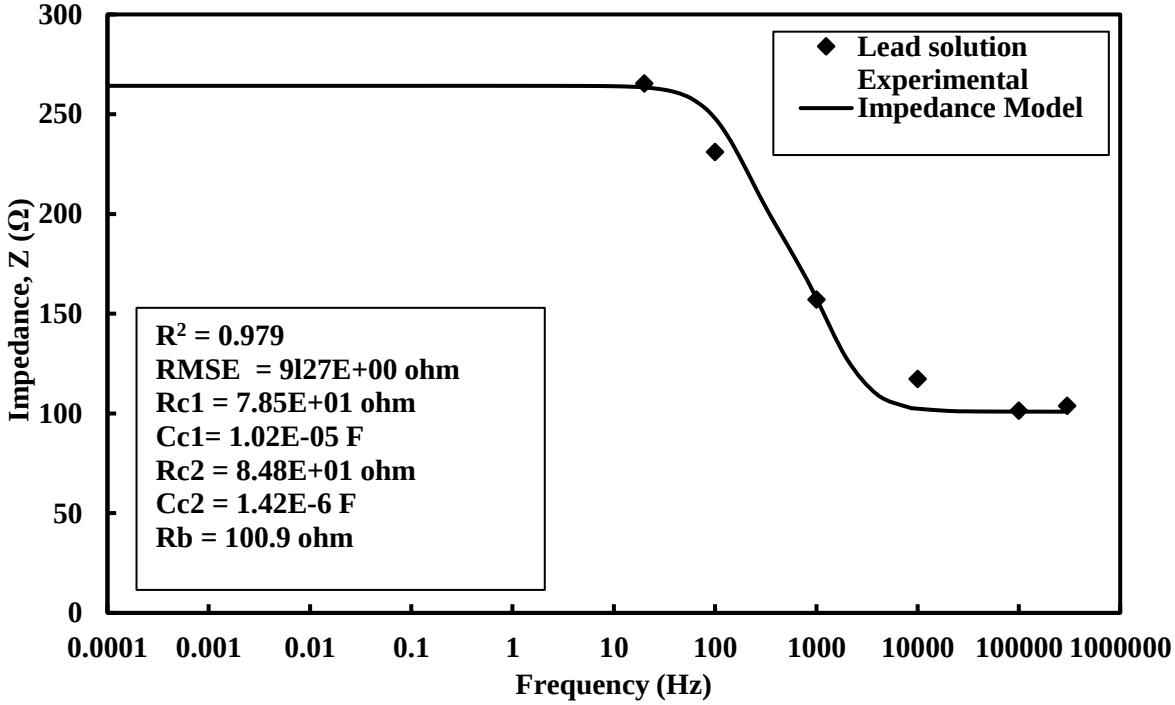

Figure 3 Impedance plot of 1% lead nitrate solution

.

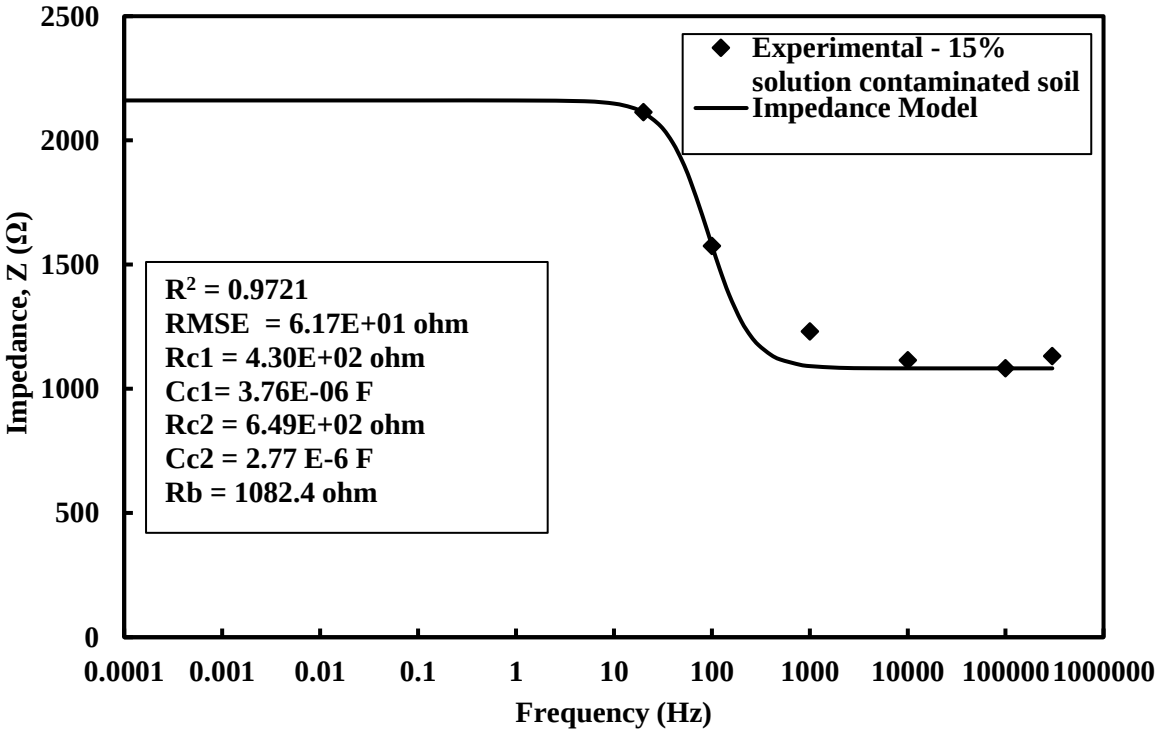

Figure 4 Impedance plot of 15% lead nitrate solution added soil

5.3 Monitoring of Vertical Resistivity and Resistance

The vertical resistivity and resistance value of lead nitrate solution and water added soil samples are shown in Figure 5-6.

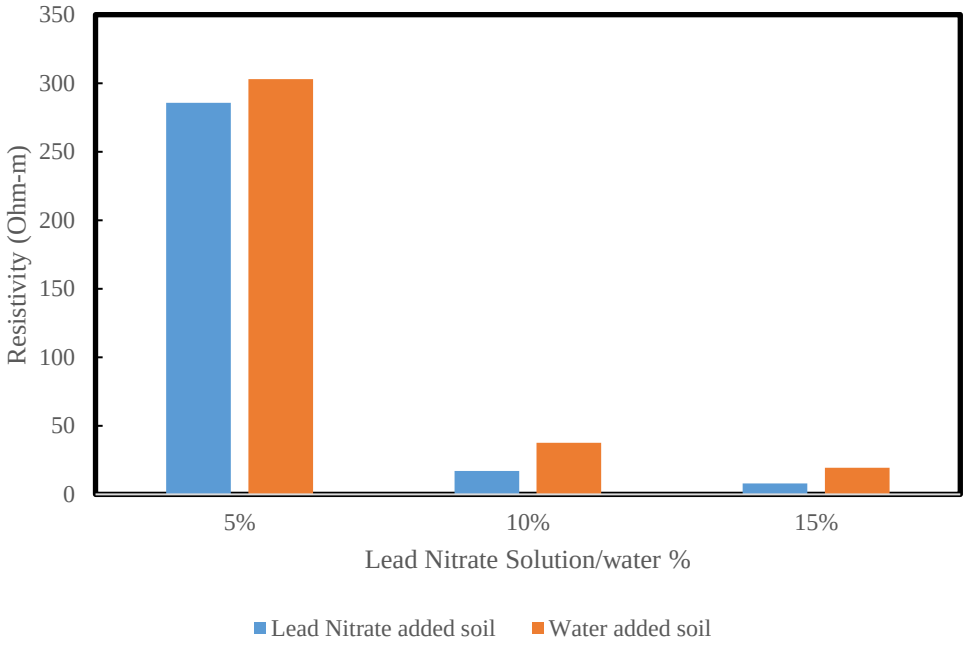

Figure 5 Vertical resistivity of soil with addition of lead nitrate solution and water

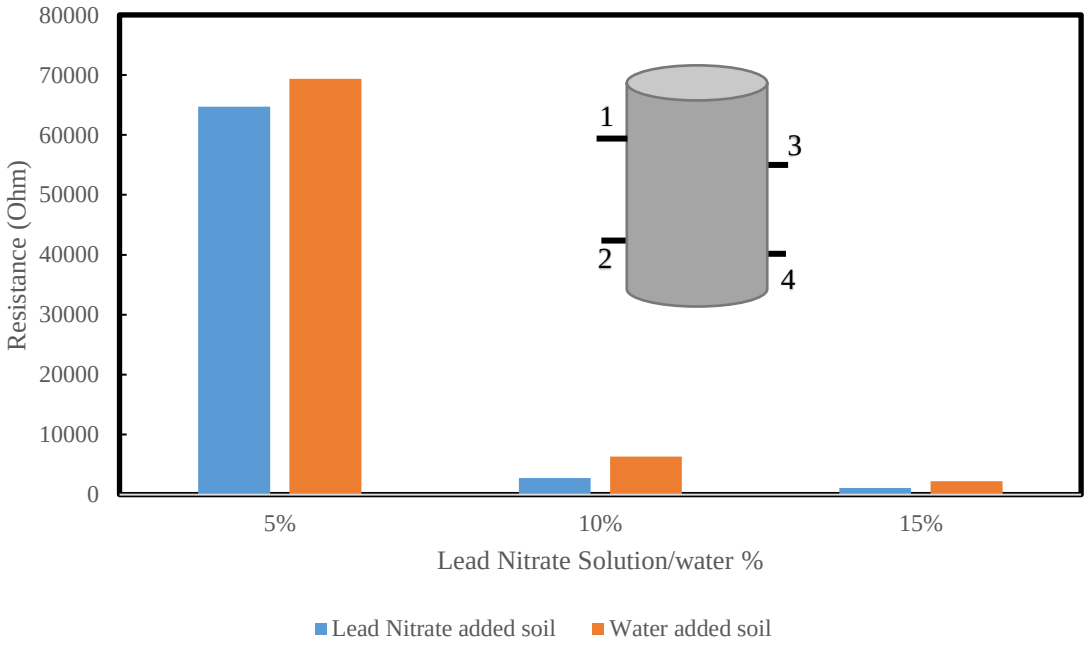

Figure 6 Vertical resistance of soil with addition of lead nitrate solution and water

With 5% of addition of lead nitrate solution, the resistivity and resistance of the soil sample slightly less than 5% water added soil sample. But 10% and 15% lead nitrate solution added soil sample had 0.4-0.5 times of resistance and resistivity than 10% and 15% water added similar configuration samples.

6 Conclusions

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

1. With the addition of lead nitrate in water from 0% to 1% the pH reduced from 7.65 to 4.41 and resistivity reduced from 26.3 to 0.9 Ohm-m.
2. Lead Nitrate solution and lead nitrate solution added soil sample follows Case 2 0f Vipulanandan Impedance model.
3. The vertical resistivity and resistance values of lead nitrate samples are lesser than water added sample for all addition percentage by 40-50%.

7 Acknowledgement

This study was supported by the Center for Innovative Grouting Materials and Technology (CIGMAT) and Texas Hurricane Center for Innovative Technology (THC -IT), University of Houston, Houston, Texas.

8 References

Karkush, M. & Ali, S., 2020. Impacts of Lead Nitrate contamination on the geotechnical properties of clayey soil. *Journal of Engineering Science and Technology*, 15(2), pp. 1032-1045.

Nasb, S. N. & Keykha, H. A., 2020. Physicochemical changes of Lead contaminted sand-clay mixture. *Spring Nature Applied Science*, 2(1531), pp. 1-15.