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Research Article

Experimental Study on Electrical Resistivity of Cement-Stabilized Lead-Contaminated Soils

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Geotechnical applications based on soil resistivity measurement are becoming more popular in recent years. In order to explore the potential application of the electrical resistivity method in stabilization/solidification of contaminated soils, two kinds of lead-contaminated soils stabilized with cement were prepared, and the electrical resistivity and unconfined compressive strength of specimens after curing for various periods were measured. The test results show that a high lead content leads to a low value of electrical resistivity of cement-stabilized soils, and increasing cement content and curing time result in a significant increase in electrical resistivity. The reduction in porosity and degree of saturation, as a result of the cement hydration process, leads to an increase in electrical resistivity. The ratio of porosity-lead content/cement content-curing time, combining together the effect of lead content, cement content, curing time, and porosity on electrical resistivity of stabilized soils, can be used as a fundamental parameter to assess electrical resistivity of cement-stabilized lead-contaminated soils. Archie's law can be extended to apply to cement-stabilized lead-contaminated soils by using this ratio, replacing the porosity. The new resistivity formula obtained in this paper is just empirical. There is a power function correlation between unconfined compressive strength and electrical resistivity of lead-contaminated soils stabilized with cement. Electrical resistivity measurement can be used as an economical and time-effective method to assess the quality of cement-stabilized lead-contaminated soils in practice.

1. Introduction

Cement stabilization/solidification (s/s) technology is a widely used method for the remediation of heavy metal-contaminated sites. In the s/s process, contaminated soils are mixed with a binder agent to lower the release of heavy metals and enhance soil strength through precipitation, chemisorption, ion exchange, and physical encapsulation [1, 2]. Many researchers have performed experimental studies on the leaching behavior, strength, and compressibility of cement-stabilized heavy metal-contaminated soils [3–6]. Heavy metals, such as lead or zinc, can suppress or delay the cement or lime hydration process [7, 8]. However, very few studies have been conducted to assess the electrical resistivity of treated contaminated soils.

The electrical resistivity measurement has increasing applications in geotechnical and geoenvironmental practices owing to its economical, time-effective, and nondestructive advantages [9–12]. Soil resistivity is a material inherent property, and the main factors influencing resistivity are water content, porosity, degree of saturation, and ion concentration of pore solution [13, 14]. Previous studies have shown that the electrical resistivity method can be used to investigate engineering properties of soils and rocks [15–22], to monitor contaminants and delineate contaminant transport in soils [10, 23–25], and to detect defects and heterogeneity in the landfill cover material [26].

For cement-based materials, Taylor and Arulanadan [27], Tashiro et al. [28], and McCarter et al. [29] reported the electrical response of the cementitious system. Li et al. [30, 31] and Xiao and Li [32] presented a new understanding of the cement hydration mechanism by using a noncontact electrical resistivity measurement method and established the relationship between resistivity and concrete setting time. Liu et al. [11] analyzed the variation of resistivity of cement-treated soils and found that there was a good correlation between resistivity and unconfined compressive strength. Zhang et al. [33] evaluated the effect of salt concentration on resistivity of cement-treated soft clays. Cardoso [12] analyzed the influence of porosity and tortuosity on electrical resistivity of artificially cemented sand. The electrical resistivity method can also be used to detect and locate crack and spalling in concrete [34–36]. It is feasible and meaningful to introduce the electrical resistivity method into the mechanism revelation and quality assessment of s/s. However, very few researchers have addressed the effect of heavy metals on electrical resistivity of cement-stabilized soils.

This study begins with a brief review of soil resistivity models. Experimental studies were performed on two kinds of artificial lead-contaminated soils stabilized with cement to investigate the effect of lead content, cement content, and curing time on electrical resistivity of stabilized soils. A resistivity empirical formula of cement-stabilized lead-contaminated soils was proposed based on Archie's law [15]. The relationship between electrical resistivity and unconfined compressive strength was also explored. This study can provide a theoretical basis for the application of the electrical resistivity method in s/s.

2. Soil Resistivity Model

The electrical resistivity of any material is defined as the resistance between opposite faces of a unit cube of that material. In previous studies, soil resistivity is modeled as an integration of resistivity of solid, liquid, and air by a parallel connection, a series connection, or a compound model of these two connections [9, 37, 38]. Archie [15] developed an empirical law to correlate electrical resistivity of saturated sand (ρ) to electrical resistivity of pore fluid (ρ_f) and porosity (n). The general Archie's law can be written as follows:

$$\rho = a \cdot \rho_\mathrm{f} \cdot n^{-m}, \tag{1}$$

where a is the fitting parameter and m is the cementation exponent. The value of m mainly depends on the interconnectivity of the pore network and tortuosity, and the full connectivity of pore fluid is achieved for $m = 1$. Archie [15] reported that the value of m ranged from 1.8 to 2.0 for consolidated sand and was tested as 1.3 for loose sand. Friedman and Seaton [39] suggested a value of $m = 1.38$–2.3 for saturated sand with a porosity of 0.3–0.49. Friedman [40] summarized the research on the value of m and found that it varied from 1.2 to 4.4 for saturated geomaterials depending on the porosity, grain size distribution, particle shape, and consolidation condition.

For unsaturated soil, soil resistivity is also related to degree of saturation. Keller and Frischknecht [41] reported that electrical resistivity of unsaturated soil (ρ) was correlated with electrical resistivity of saturated soil (ρ_sat) by the following equation:

$$\frac{\rho}{\rho_{sat}} = S_\mathrm{r}^{-b}, \tag{2}$$

where S_r is the degree of saturation and b is the empirical factor.

In order to better understand the resistivity behavior of cement-stabilized heavy metal-contaminated soils, it is necessary to establish a corresponding resistivity formula. However, the influence of the cement hydration process on soil resistivity cannot be reflected in Equations (1) and (2). Cardoso [12] pointed out that Archie's law may not be valid for cement-treated materials. Therefore, in this paper, we just present an empirical resistivity formula that can take account of the influence factors of electrical resistivity of cement-stabilized soils, based on the parameter porosity in Archie's law.

3. Materials and Methods

3.1. Materials. Two soils (S1 and S2) were used in this study. Soil S1 was obtained by mixing 15% kaolin and 85% sand by oven-dried weight. Soil S2 was collected from the Jiulonghu campus of Southeast University in Nanjing City, China. Physical parameters of kaolin and S2 are shown in Table 1, and grain size distribution curves of kaolin, sand, and S2 are shown in Figure 1. According to the Unified Soil Classification System [42], soil S1 is classified as clayey sand and soil S2 is classified as lean clay. The optimum moisture content and maximum dry density are 10.0% and 1.96 g/cm^3 for soil S1 and are 12.4% and 1.91 g/cm^3 for soil S2, with the standard Proctor compaction test [43].

Lead was selected as the target heavy metal since it is commonly encountered in contaminated sites worldwide, especially in China [8]. Lead nitrate was selected as the lead pollutant resource because it has a high solubility and nitrate ion has a low impact on the cement hydration process [7]. Ordinary Portland cement type I was used as the binder. The main chemical compositions of cement are 65.0% calcium oxide, 19.0% silicon dioxide, and 6.5% aluminum oxide.

3.2. Sample Preparation. In order to obtain a homogeneous mixture, air-dried soil was passed through a 2 mm sieve and admixed with cement power for about 10 min, and then it was mixed with a certain volume of prepared lead nitrate solution with the desired lead content for another 10 min. The mixture was then compacted into a cylindrical mold having a 5 cm inner diameter and a 10 cm height with the optimum water content (10.0%) and maximum dry density (1.96 g/cm^3) for the specimen of soil S1 and with a water content of 18.0% and 95% maximum dry density for the specimen of soil S2. After standing without disturbance in the mold for 3 h, the specimens were demolded, sealed in polyethylene bags, and cured at a constant temperature of 20 ± 2°C and a relative humidity of 95%. The electrical resistivity measurement and unconfined compressive test were conducted when the specimens were cured to a predetermined period.

The experimental scheme is presented in Table 2. According to the monitoring results of foundation soil of a chemical plant in Nanjing City, China, lead contents (termed as w_Pb) were selected as 0.1%, 1%, and 3% (i.e., 1000 mg/kg, 10000 mg/kg, and 30000 mg/kg dry soil) for the specimen of soil S1 and as 0.1%, 0.5%, and 2.5% (i.e., 1000 mg/kg, 5000 mg/kg, and 25000 mg/kg dry soil) for the specimen of soil S2, typically. For comparison, controlled specimens without lead (i.e., 0 mg/kg) were also prepared. Cement

Table 1: Physical parameters of kaolin and soil S2 used in this study.

Soil type	Liquid limit (%)	Plastic limit (%)	Specific gravity	Sand (%) (>0.075 mm)	Silt (%) (0.075–0.002 mm)	Clay (%) (<0.002 mm)
Kaolin	68.0	32.0	2.72	0.0	80.0	20.0
S2	44.0	16.9	2.71	11.0	74.8	14.2

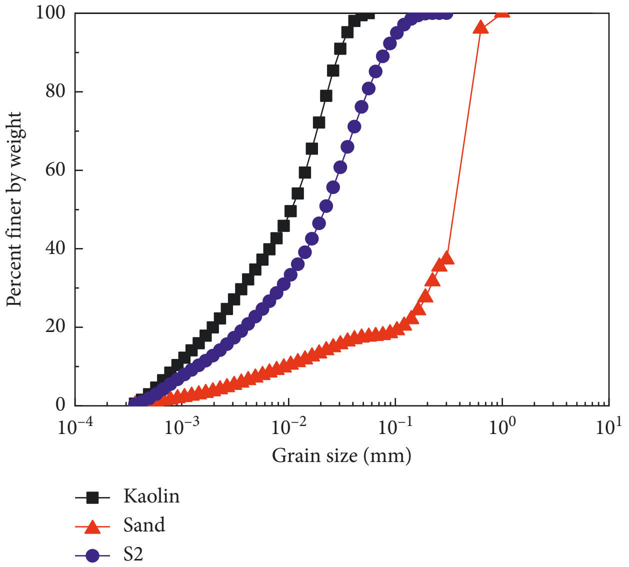


Figure 1: Grain size distribution curves of soils used in this study.

Table 2: The lead content, cement content, and curing time for electrical resistivity measurement.

Soil type	Lead content (w_{Pb}, %)	Cement content (a_{w}, %)	Curing time (T, d)
S1	0, 0.1, 1, 3	5, 7.5, 10	7, 14, 28, 56, 90
S2	0, 0.1, 0.5, 2.5	9, 12, 15	7, 14, 28

contents (termed as a_{w}) were set as 5%, 7.5%, and 10% (on the dry soil weight basis) for the specimen of soil S1 and as 9%, 12%, and 15% (on the dry soil weight basis) for the specimen of soil S2, as recommended by Kogbara and Al-Tabbaa [44].

3.3. Test Methods. Before electrical resistivity measurement, the volume and mass were measured to calculate the density of specimens. The electrical resistivity of each specimen was measured using a GW Instek LCR-817 apparatus with a plate two-electrode method. Two copper electrodes, with a thickness of 2 mm and a diameter of 50 mm, were placed on the top and at the bottom of the specimens during electrical resistivity measurement. A vertical pressure of 5 kPa was applied on the copper electrodes to make the specimen and copper electrode in a good contract. This pressure was found to have a negligible effect on the electrical resistivity and strength of the specimen. In order to avoid the influence of the electrode polarization effect and double-layer relaxation effect [15, 33], the frequency used to measure electrical resistivity was selected as 2 kHz. Electrical resistivity tests were carried out at a constant temperature of 20 ± 2°C. The schematic diagram of a specimen resistivity test is shown in Figure 2.

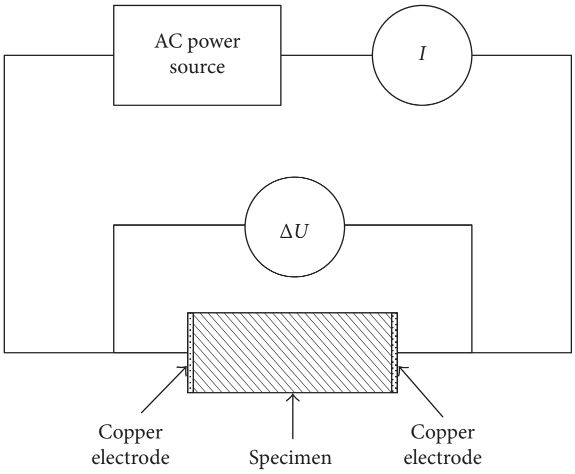


Figure 2: Schematic diagram of the electrical resistivity test.

The electrical resistivity of the specimen can be determined by the following equation:

$$\rho = \frac{\Delta U}{I} \cdot \frac{S}{L}, \tag{3}$$

where ρ is the electrical resistivity of the specimen (Ω·m), ΔU is the electrical voltage applied to the specimen (V), I is the electrical current (A), S is the cross-sectional area through which electrical current conducts (m^2), and L is the length of the specimen parallel to electrical current (m).

After electrical resistivity measurement, the unconfined compressive test was performed following the method of ASTM D2166/D2166M-16 at a strain rate of 1%/min [45]. The water content of the specimen was also measured after the unconfined compressive test.

Triplicate specimens were tested for electrical resistivity measurement and unconfined compressive test, and the average values of test results were presented, analyzed, and discussed in this study.

3.4. Data Analysis Methods. In order to assess the effectiveness of Archie's law in the application of cement-stabilized lead-contaminated soils, the porosity of the specimen at various curing times (n_t) was determined by the void ratio at various curing times (e_t) using Equation (4). The void ratio was calculated by using the solid-liquid-air phase concept:

$$n_t = \frac{e_t}{1 + e_t}, \tag{4}$$

$$e_t = \frac{(1 + \omega_t) G_{\mathrm{s}} \gamma_{\mathrm{w}}}{\gamma_t} - 1, \tag{5}$$

where ω_t is the water content at various curing times, which was measured after the unconfined compressive test; γ_t is the unit weight of stabilized soils (kN/m^3), which was determined based on the calculation results of density; γ_w is the unit weight of water (kN/m^3); and G_s is the composite specific gravity of stabilized soils [33], which was derived as the mass-weighted mean of each solid ingredient, including soil, cement, and lead nitrate. The values of specific gravity of kaolin, sand, soil S2, cement, and lead nitrate are 2.72, 2.68, 2.71, 3.10, and 4.53, respectively. Degree of saturation of samples was also calculated by using the solid-liquid-air phase concept, based on the test results of water content (ω_t) and the calculation results of specific gravity (G_s) and void ratio (e_t) of stabilized soils.

4. Results, Analysis, and Discussion

4.1. Effect of Lead Content, Cement Content, and Curing Time on Electrical Resistivity. For specimens of soil S1, the variations of electrical resistivity with lead content, cement content, and curing time are shown in Figure 3. The lead content plays a key role in electrical resistivity of stabilized soils. As shown in Figure 3, the electrical resistivity decreases with the increase of lead content. The electrical resistivity of specimens with 0.1% lead content is slightly lower than that of specimens without lead (controlled specimens); for specimens with 1% and 3% lead content, the electrical resistivity is significantly lower than that of controlled specimens. The effect of lead content on resistivity of cement-stabilized soils can be found in two aspects: firstly, the addition of lead nitrate induces an increasing trend in the ion concentration of pore solution, and the presence of ions enhances the electrical current flow [13, 14]. As a result, the electrical resistivity of pore solution decreases with the increase of lead content. Secondly, the high lead content in soils greatly suppresses or delays the cement hydration process [7]. The generation of cement hydration products is suppressed, which consequently leads to a low value of electrical resistivity.

Figure 3 also shows that electrical resistivity of cement-stabilized soils increases with the increase of cement content. This can be interpreted by the cement hydration process. Higher cement content leads to a greater amount of hydration products, such as calcium hydroxide and calcium silicate hydrate. These products fill in the pore spaces and intersect each other, resulting in a denser structure in soils. Moreover, the consumption of free water, as a result of hydration reaction, further increases the pore tortuosity for electric current. Consequently, soil resistivity increases obviously with the increase of cement content. However, owing to cement hydration, the mobile ions in cement, such as calcium (Ca^{2+}), ferric (Fe^{3+}), and magnesium (Mg^{2+}), dissolve into the pore water. The presence of these ions leads to a decrease in electrical resistivity of pore solution. The increase of electrical resistivity with the increase in cement content marks a competition process between the ion dissolving process and the solid phase nucleation in the cement hydration process.

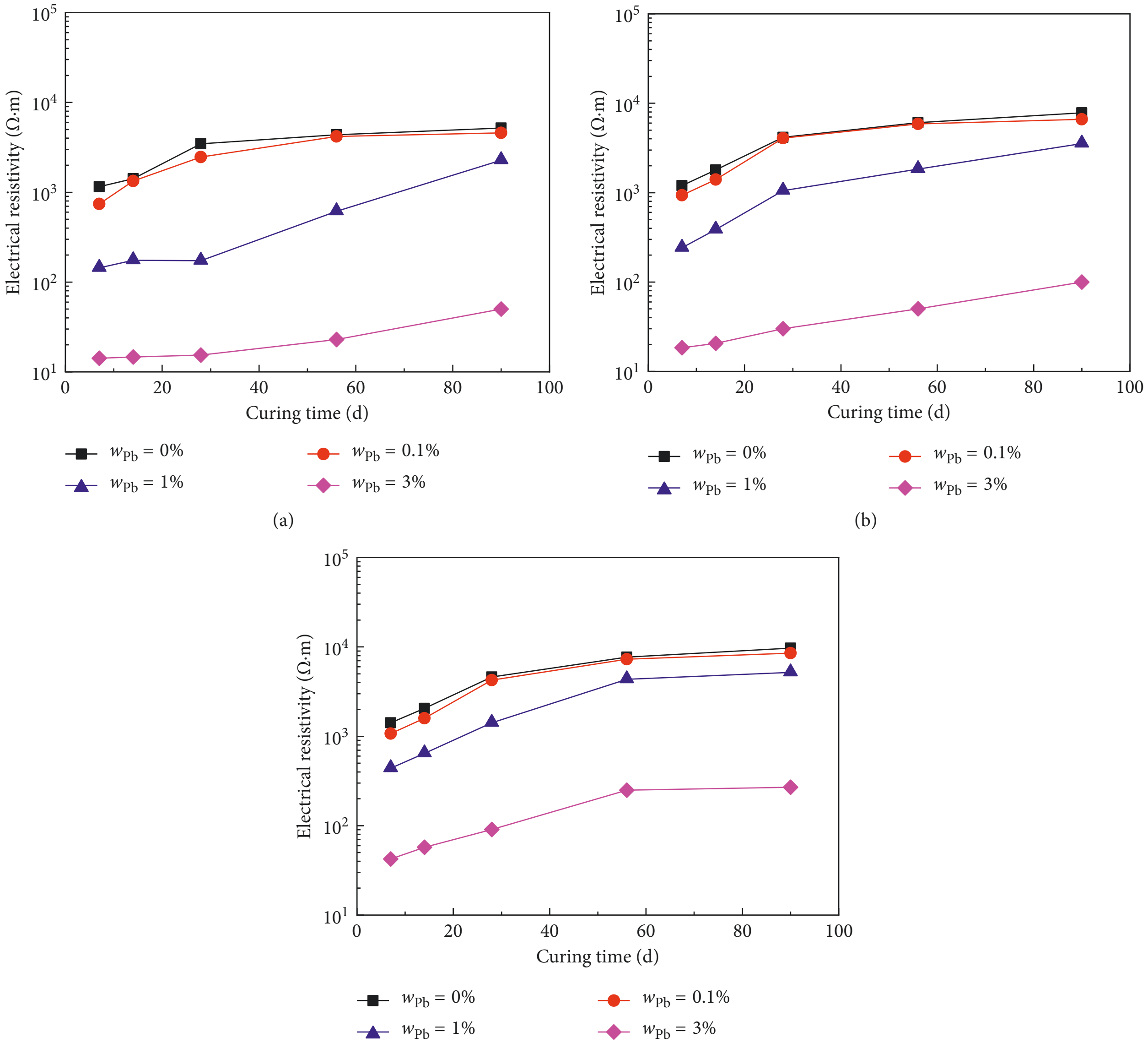
In addition, increasing curing time results in a significant increase in electrical resistivity, as shown in Figure 3. Longer curing time leads to a greater amount of hydration products, and the formation of hydration products is the main reason for the increase in electrical resistivity [11]. With the development of hydration reaction, a certain amount of ions, such as Ca^{2+}, are involved with the formation of hydration products. As a result, the pore solution concentration decreases and the electrical resistivity of pore solution increases. For specimens without lead or with 0.1% lead content, the electrical resistivity increases distinctly before curing for 28 days and then tends to be steady. However, the variations of electrical resistivity with curing time are different at various cement contents, for specimens with 1% or 3% lead content. These phenomena are attributed to the cement hydration rate depending on lead content and cement content [7, 46].

Figure 4 shows the electrical resistivity of specimens of soil S2. The variations of electrical resistivity with lead content, cement content, and curing time are consistent with those of specimens of soil S1.

4.2. Electrical Resistivity with Porosity. As mentioned by Archie [15], soil resistivity mainly depends on the porosity. Figure 5 shows the relationship between electrical resistivity and porosity. When lead content is certain, an increase in electrical resistivity is observed with the decrease in porosity. For cement-stabilized soils, hydration products fill in the pore spaces, leading to a decrease in porosity and an increase in pore tortuosity. As a result, electrical resistivity increases with the reduction of porosity. The test results from specimens of soils S1 and S2 all show similar trends with Archie's law. However, it can be seen that there is a large scatter of data of specimens of both soil S1 and soil S2. Archie's law is based on saturated sand without cement hydration process; the porosity parameter cannot fully reflect the effect of the hydration process and pozzolanic reaction on electrical resistivity in cement-stabilized soils.

It should be noted that Archie's law is a generalized law for pure sandy samples. The clay content in particular makes ineffective such a kind of relationship between electrical resistivity and porosity, owing to the effect of the electric double layer of the clay particle [14]. Some researchers have reported the limitation of Archie's law in case of no pure sandy samples [14, 47, 48]. The soils used in this study, S1 and S2, have clay contents. But for stabilized soils, cement can reduce the thickness of the electric double layer of the clay particle [49]. As a result, the effect of clay contents on electrical resistivity is weakened and even can be ignored.

4.3. Electrical Resistivity with Degree of Saturation. Degree of saturation is also one of the key factors influencing soil resistivity [13, 41]. Figure 6 shows the relationship between electrical resistivity and degree of saturation of cement-stabilized soils. The consumption of pore water, owing to hydration reaction, leads to a reduction in degree of saturation and a decrease in connectivity of pore solution. Therefore, electrical resistivity increases with the reduction in degree of saturation at a given lead content, as shown in Figure 6. For both specimens of soils S1 and S2, the variations of measured electrical resistivity with degree of



(a)

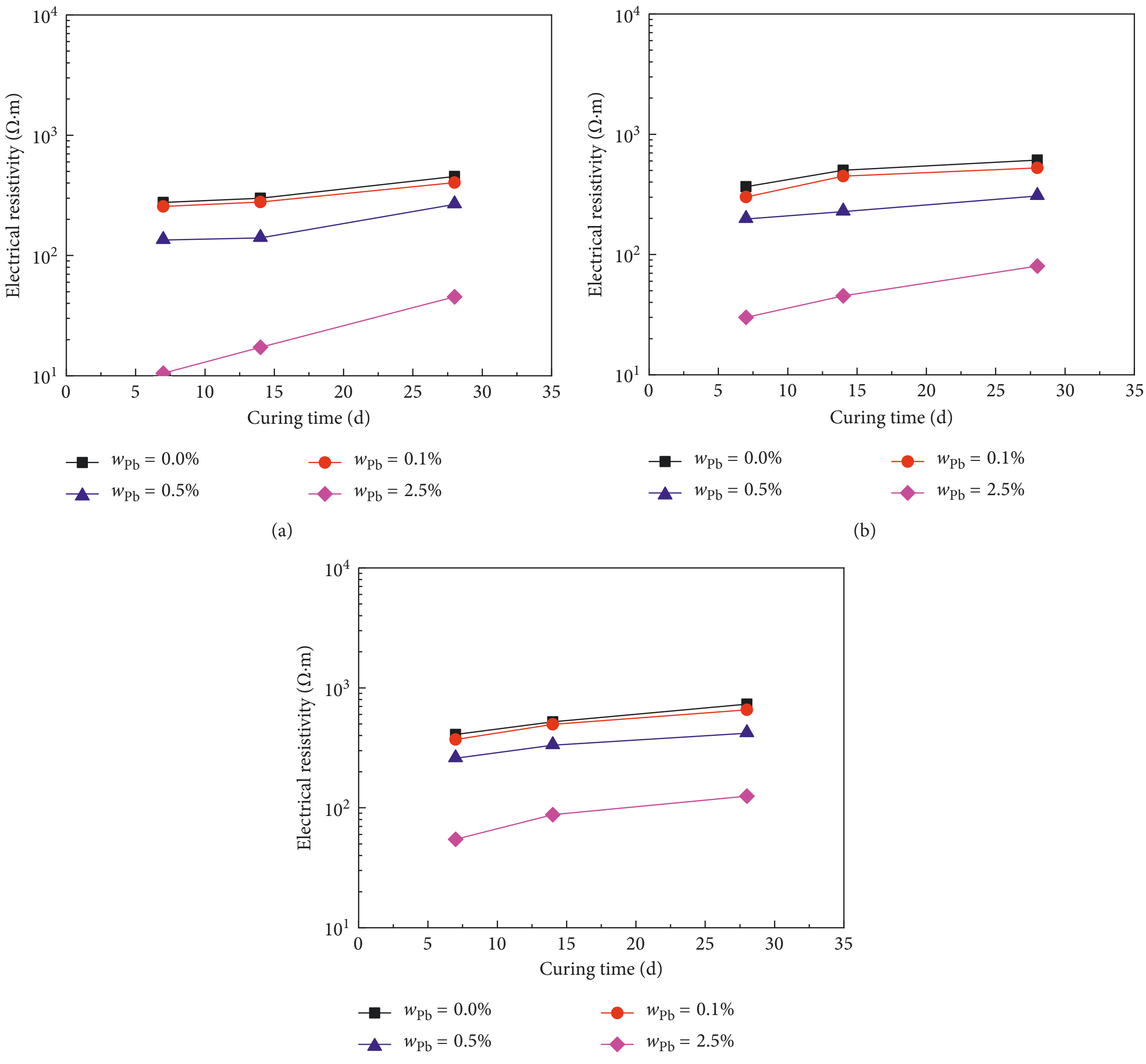
(b)

(c)

FIGURE 3: Variation of electrical resistivity with curing time of specimens of soil S1: (a) $a_w = 5\%$; (b) $a_w = 7.5\%$; (c) $a_w = 10\%$.

saturation are consistent with the experimental results obtained by Kibria and Hossain [13]. However, the dispersion of data is also obvious. The effect of the cement hydration process and pozzolanic reaction on electrical resistivity cannot also be effectively reflected by degree of saturation.

4.4. Resistivity Empirical Formula of Cement-Stabilized Lead-Contaminated Soils. As mentioned earlier, porosity or degree of saturation cannot be used alone as a key parameter controlling electrical resistivity of cement-stabilized lead-contaminated soils. The electrical resistivity is also dependent on lead content, cement content, and curing time. It is logical to utilize a synthetic parameter combining together the effect of these factors. Zhang et al. [33] proposed a parameter, termed as the "porosity/cement content-curing time ratio," $n_t/(a_w \cdot T^{0.5})$, which can reflect the effect of the cement hydration process and soil compactness on electrical resistivity of cement-treated soils without lead. The variation of measured electrical resistivity in this study with the ratio of porosity/cement content-curing time is shown in Figure 7. For specimens of soil S1 or S2, there is a good correlation between this ratio and electrical resistivity at a given lead content. The effect of lead content on electrical resistivity cannot be reflected by this ratio. By means of regression analysis of the test data, a new parameter, termed as the "porosity-lead content/cement content-curing time ratio," $(n_t \cdot \alpha^{100 w_{Pb}})/a_w \cdot T^{0.5}$, is proposed. It is worth pointing out that α is a fitting parameter, which is related to the influence level of lead on electrical resistivity of cement-stabilized soils. In this study, the value of α is 2 for specimens of soils S1 and S2. It may be a different value for other kinds of heavy metals.



(a)

(b)

(c)

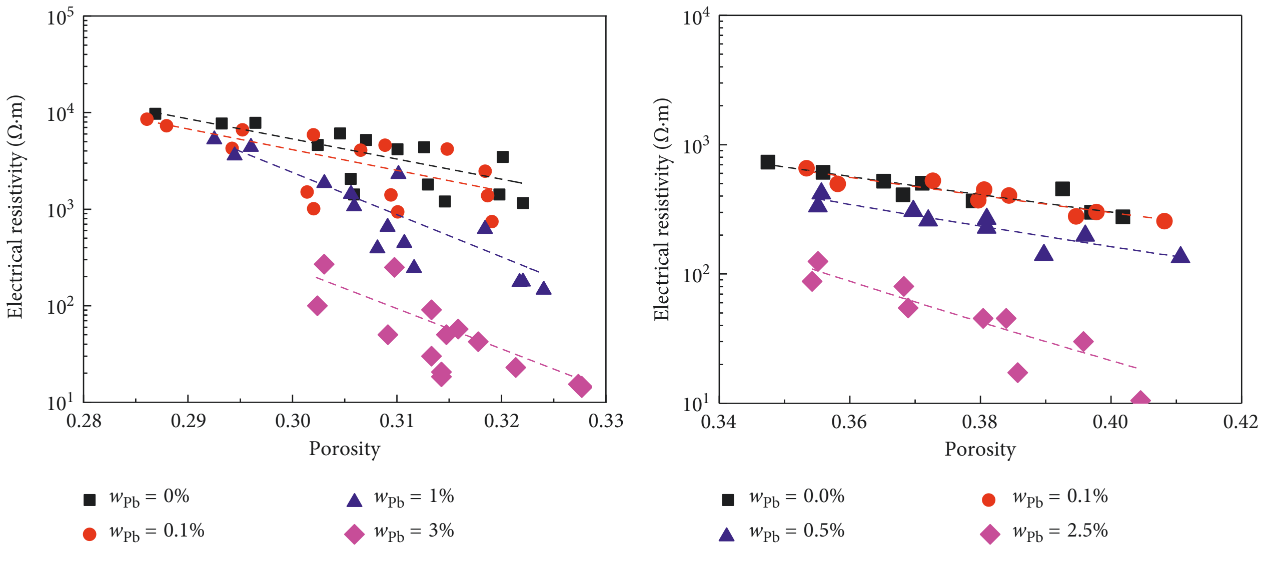
FIGURE 4: Variation of electrical resistivity with curing time of specimens of soil S2: (a) $a_w = 9\%$; (b) $a_w = 12\%$; (c) $a_w = 15\%$.

Figure 8 shows a good correlation between electrical resistivity and the ratio of porosity-lead content/cement content-curing time. The coefficients of determination (R^2) are all 0.94 for specimens of soils S1 and S2. It is indicated that the new ratio can combine together the effect of these factors, including lead content, cement content, curing time, and porosity, on electrical resistivity of stabilized soils. The resistivity empirical formula of cement-stabilized lead-contaminated soils can be expressed as follows:

$$\rho = A\left[\frac{\left(n_t \cdot \alpha^{100w_{\mathrm{Pb}}}\right)}{\left(a_{\mathrm{w}} \cdot T^{0.5}\right)}\right]^{-B}, \qquad (6)$$

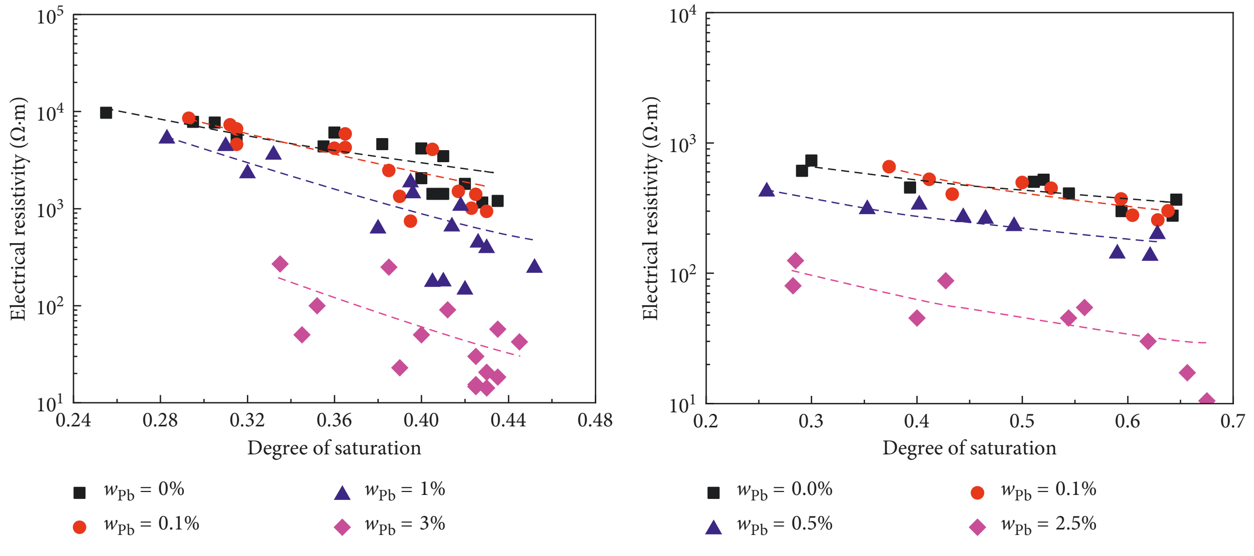
where $\alpha = 2$ and A and B are empirical constants. The parameter A is mainly dependent on the type of soil and water content; the value of B, similar to the cementation exponent in Archie's law [15], mainly depends on the pore connectivity and soil compactness. In this study, the values of A and B are 1982 and 1.87 for specimens of soil S1 and are 335 and 1.25 for specimens of soil S2.

Comparing Equations (1) and (6), it is interesting to find that the resistivity formula proposed in this study is similar to Archie's law. That is to say, Archie's law can be extended to apply to cement-stabilized heavy metal-contaminated soils by using a synthetic parameter, termed as the "porosity-lead content/cement content-curing time ratio," $(n_t \cdot \alpha^{100w_{\mathrm{Pb}}})/a_{\mathrm{w}} \cdot T^{0.5}$. When lead content is 0%, this formula can be returned to the resistivity formula of cement-treated soils without lead developed by Zhang et al. [33]. It should be noted that this synthetic parameter has no specific physical meaning, and Equation (6) is an empirical resistivity formula.



(a) (b)

Figure 5: Variation of electrical resistivity with porosity: (a) specimens of soil S1; (b) specimens of soil S2.



(a) (b)

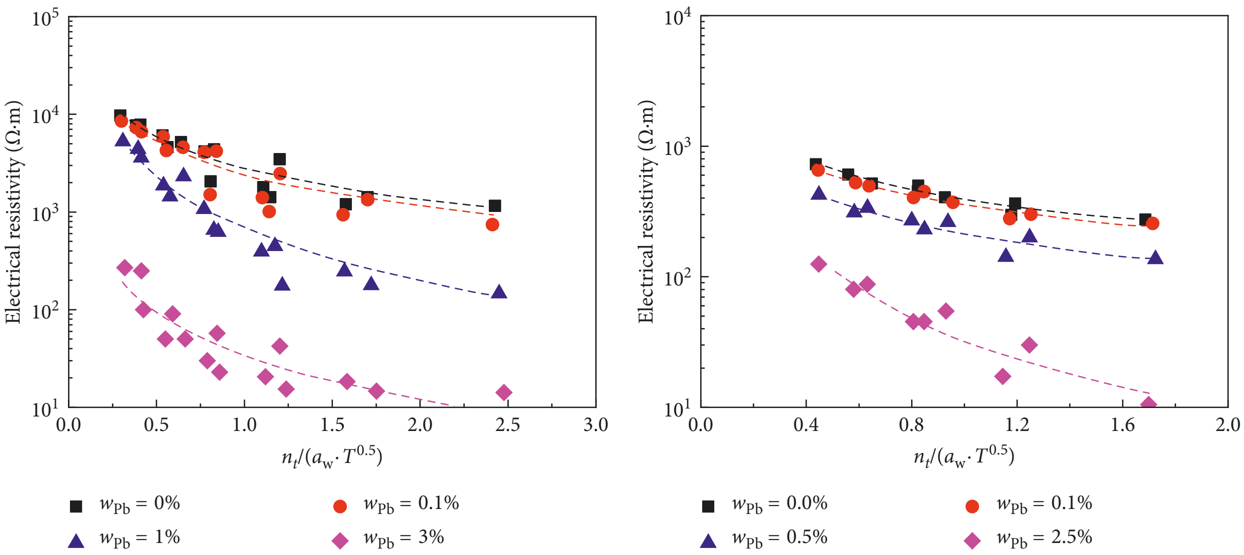
Figure 6: Variation of electrical resistivity with degree of saturation: (a) specimens of soil S1; (b) specimens of soil S2.

In addition, the degree of saturation of samples is not considered in this synthetic parameter. This may indicate that the effect of degree of saturation on electrical resistivity of stabilized soils is lower than that of lead content, cement content, and curing time. The good correlation between electrical resistivity and the ratio of porosity-lead content/cement content-curing time is sufficient for engineering applications. It may not be necessary to introduce degree of saturation into this ratio. However, for unsaturated soils without cement hydration process, degree of saturation is very important and cannot be ignored [13].

The resistivity empirical formula reveals the influence factors of electrical resistivity. The result shows that a unique power function adapts well electrical resistivity with the ratio of porosity-lead content/cement content-curing time. Therefore, this ratio can be used as a fundamental parameter sufficient to characterize electrical resistivity of cement-stabilized lead-contaminated soils. The ratio can also be used to monitor and control the quality of s/s.

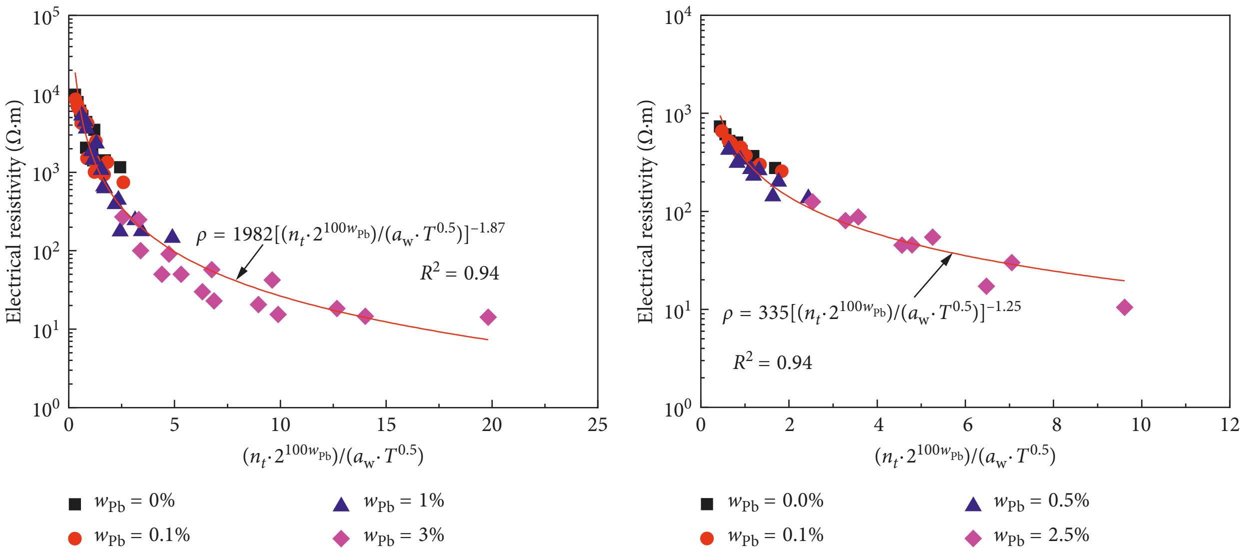
4.5. Relationship between Electrical Resistivity and Unconfined Compressive Strength.

Unconfined compressive strength is an important parameter for evaluating the effectiveness of s/s [50]. Figure 9 presents the relationship between measured strength and electrical resistivity. The strength of



(a) (b)

FIGURE 7: Relationship between electrical resistivity and $n_t/a_w \cdot T^{0.5}$: (a) specimens of soil S1; (b) specimens of soil S2.



(a) (b)

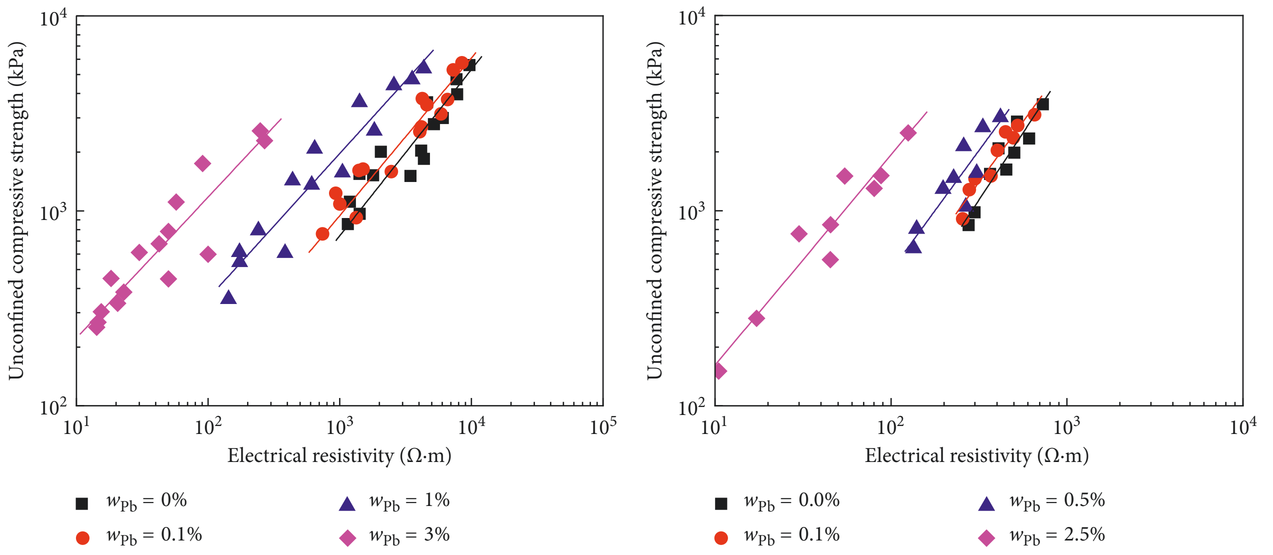
FIGURE 8: Relationship between electrical resistivity and $(n_t \cdot 2^{100w_{Pb}})/a_w \cdot T^{0.5}$: (a) specimens of soil S1; (b) specimens of soil S2.

stabilized soils primarily depends on cement hydration products and pore structure of soil, which are also the main factors affecting electrical resistivity. Therefore, unconfined compressive strength can be related to the electrical resistivity of cement-stabilized soils, as shown in Figure 9. The result shows that the relationship between strength and electrical resistivity is not unique and depends on lead content. The presence of lead not only hinders the cement hydration process but also changes the ion concentration of pore solution. The former can delay the development of strength and electrical resistivity, and the latter mainly affects the resistivity of stabilized soils. The influence mechanisms of lead on strength and electrical resistivity of stabilized soils are not exactly the same, resulting in different relationships at different lead contents.

As shown in Figure 9, there is a power function correlation between unconfined compressive strength and electrical resistivity at a given lead content, expressed as follows:

$$q_u = C \cdot \rho^D, \tag{7}$$

where q_u is the unconfined compressive strength and C and D are empirical constants, which depend on lead content



(a)

(b)

Figure 9: Relationship between unconfined compressive strength and electrical resistivity: (a) specimens of soil S1; (b) specimens of soil S2.

Table 3: Empirical constants between unconfined compressive strength and electrical resistivity.

Soil type	Lead content (%)	C	D	R^2
S1	0	2.0	0.85	0.86
	0.1	3.5	0.81	0.90
	1	11.5	0.75	0.94
	3	42.1	0.72	0.85
S2	0.0	0.4	1.37	0.82
	0.1	1.1	1.24	0.89
	0.5	1.7	1.23	0.76
	2.5	13.5	1.08	0.88

and are listed in Table 3. The value of C increases significantly with the increase in lead content and is also related to soil type. The value of D, ranging from 0.72 to 0.85 for specimens of soil S1 and from 1.08 to 1.37 for specimens of soil S2, is also related to soil properties. When $D = 1$, Equation (7) presents a linear relationship between strength and electrical resistivity, which is similar to the results reported by Liu et al. [11] and Zhang et al. [33].

As shown in Table 3, the correlation coefficient (R^2) of Equation (7) is higher than 0.85 for specimens of soil S1 and is higher than 0.76 for specimens of soil S2. It is indicated that unconfined compressive strength can be correlated with electrical resistivity of cement-stabilized soils. Therefore, the electrical resistivity method can be used as a time-effective and economical technology to quantify the mechanical behavior of cement-stabilized heavy metal-contaminated soils in the field. Combining the resistivity formula developed in this study, engineers can choose a proper amount of cement to meet the strength requirement of the actual project, taking into account the effect of lead.

5. Conclusions

This study investigated the effect of lead content, cement content, and curing time on electrical resistivity of stabilized soils, proposed a resistivity empirical formula of cement-stabilized lead-contaminated soils based on Archie's law, and explored the relationship between unconfined compressive strength and electrical resistivity. Based on the experimental results, analysis, and discussion reported, the specific conclusions can be drawn as follows:

(i) The electrical resistivity of lead-contaminated soils stabilized with cement decreases with the increase in lead content and increases with the increase of cement content and curing time. The reduction in porosity and degree of saturation, as a result of the cement hydration process, leads to an increase in electrical resistivity of stabilized soils.

(ii) A unique power function well adapts electrical resistivity with the ratio of porosity-lead content/cement content-curing time, $(n_t \cdot \alpha^{100w_{\mathrm{Pb}}})/a_w \cdot T^{0.5}$. This ratio can be used as a fundamental parameter to assess electrical resistivity of cement-stabilized lead-contaminated soils.

(iii) Archie's law can be extended to apply to cement-stabilized lead-contaminated soils by using the ratio of porosity-lead content/cement content-curing time, replacing the porosity. It should be noted that this ratio has no specific physical meaning, and Equation (6) is just an empirical resistivity formula.

(iv) There is a power function correlation between unconfined compressive strength and electrical resistivity of cement-stabilized lead-contaminated soils.

Electrical resistivity measurement can be used as an economical and time-effective method to assess the quality of cement-stabilized lead-contaminated soils in practice.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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