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Detection of Leachate Contamination in Soil Using Electrical Resistivity Method.

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Abstract. This article provides information on the electrical resistivity method, which can be used to determine soil contamination by an indirect method. Soil and leachate samples were collected from Turamuri village, Belagavi taluk and district in an area. Moulds with a diameter of 7.5 cm were fabricated using PVC material. Different percentages of pollutants (leachate) were artificially added to the soil. The mixture was compacted in the mould for 3 void ratios (0.7, 0.8, 0.9) and 3 moisture contents (23%, 24%, 25%) and the electrical resistivity of the soil was measured (by Wenner method). After completion of the tests, the result is a calibration curve of the soil for different contaminant concentrations as a function of different void ratios and moisture contents, which can be used to determine and identify the presence of leachate contaminants in the soil. The main objective of this study is to use the electrical resistivity method to detect the contamination in an indirect method. This method provides faster results than chemical analysis, but requires the preparation of a calibration table in the laboratory.

Keywords: Leachate, Electrical Resistivity Method, Soil, Mould, Contaminants.

1 Introduction

1.1 General

The sudden increase in industrial use of land from the 17th century onward has left a legacy of derelict and polluted sites in much of the developed world. In some areas of the developing world, rapid economic and technological growth is increasing the magnitude of the problem. Often, industrial processes have accidentally or otherwise resulted in chemical spills or leaks. These chemicals then entered the soil and from there could contaminate groundwater supplies or remain in the soil until removed at a later date. In recent years, more attention has been paid to the remediation of contaminated soils for a variety of reasons, including demand for building land and environmental regulations, resulting in increased research into appropriate technologies for this purpose. Leachate is formed when rainwater percolates through the landfill and dissolves the inorganic and organic materials of solid waste, which may enter the groundwater and the environment [1].

Electrical resistivity is a traditional method for determining geophysical and electrical properties used for leachate exploration and geotechnical work [2]. The effects of leachate on soil degrade the quality of soil both in physicochemical and mechanical aspects.

The presence of leachate contaminates the soil was known before, but the proper test that can be used to make a quality study of the nature of the soil and also to determine the composition of the leachate has never been known. In this work, an experimental study was carried out in which the electrical resistivity was measured in different soil samples with different percentages of multiple inclusions, using the experimental data according to previous experiments to obtain the desired value for the uncontaminated soil sample, which in turn was used as a reference point or reference for the next contaminated samples [3, 4]. Leachate is a harmful and hazardous liquid that can have negative impacts on soil and water table [5]

Impacts due to leachate. Leachate contains a high organic and inorganic load as well as heavy metals. If landfill is not properly managed, it can cause serious environmental threats [6]. Leachate migration from waste sites or landfills and the release of contaminants from sediments (under certain conditions) pose a high risk to groundwater resources if not properly managed. The movement of leachate in the landfill [7, 8].

The main objective of the project is to use the electrical resistivity method to detect contaminants in soil and to establish a calibration chart/curve for the Turmuri site.

1.2 Location & Site Details

Initially, the solids waste management in Belagavi city was one of the major problem face by the city corporation to overcome this problem, City Corporation Belagavi has constructed an integrated municipal solid waste treatment and disposal plant in Turamuri village, Belagavi taluk and district. The plant is located on an area of 26.7 hectares in Turamuri village, Belagavi district and Karnataka, The Fig. 1 shows the topographic map of the project site (10 km radius) and the "project boundary" on the Google map. Solid waste was dumped on the site as shown in Fig. 2.

Fig. 1. Turmuri Site

Fig. 2. Landfill

2 Methodology

In the process, first went to the waste management company to get an overview of the site with the company's permit letter. Then talked to the engineer there and explained project and told them what materials we needed for this project. They agreed and gave permission to take the soil samples and leachate. The required amount of soil and leachate was collected at a specific location. Airtight containers were used to store leachate. The soil must be dried in the oven and then stored. Basic tests performed on soil samples with different percentages of leachate for different moisture contents and different densities.

Basic tests performed on soil samples include the standard proctor test, wet sieve analysis/hydrometer analysis, specific gravity, liquid limit, plastic limit, and unconfined compression test. All tests are performed according to the regulations of IS codes.

Set-up Moulds were made from PVC or acrylic tubes with a diameter of 3". Mild steel nails and aluminium wire with a diameter of 3 mm are used as electrodes. A digital multi meter displays the potential difference, and the current is supplied through the power supply DC. Wenner's method is used to determine the electrical resistance. The entire work was planned as shown in Fig. 3.

Formula to calculate resistivity

$$\rho_a = 2\pi a \frac{\Delta V}{I} \quad (1)$$

Fig. 3. Flowchart showing the work plan

PROCEDURE:

a) The PVC mould should be clean from the inside and close one end of the pipe.
b) Pour the prepared soil slurry saturated with leachate in the required amount. Make sure there are no air voids or soil lumps .if there are, they should be removed.
c) Insert the four electrodes into the sample and close the hole points perfectly.
d) Install the voltmeter and ammeter to measure the respective current and voltage, and connect them to two electrodes each.
e) Using cables, DC power is supplied and the readings of voltmeter and ammeter are recorded for different setups.
f) The test is performed for different setups with different pollution concentrations. As shown in Fig. 4 .
g) After all the required tests are completed, based on the formulas will calculate the resistance or we can say resistivity of the soil.
h) Then the calibration chart is prepared for the future test to be conducted at that particular site. Based on the calibration chart we can say how much the soil is contaminated after the test.

Fig. 4. Set-up for the test

3 RESULTS AND DISCUSSION

3.1 Basic Tests Results

The Turamuri waste disposal facility in Belagavi was visited to collect leachate and soil samples on site. The basic tests shown in Table 1 were performed on the soil sample.

Table 1. Properties of soil

TESTS	RESULTS
Specific Gravity [9]	2.6
Standard Proctor Test [10]	Maximum dry density =15.3 kN/m^3 Optimum moisture contains= 24 %
Wet Sieve Analysis / Hydrometer Analysis Test [11]	Gravel= 0%, Sand= 14%, Silt= 28%, Clay= 58%
Liquid Limit [12]	43 %
Plastic Limit [12]	20%
Unconfined Compression Test [13]	Average unconfined compressive stress = 63 kN/m^2 Angle of internal friction = 0 Undrained cohesive strength c = 31 kN/m^2

3.2 Electrical Resistivity Test results.

As can be seen in Fig. 5, Fig. 6, and Fig. 7, the electrical resistivity for the mild steel electrode with a void ratio 0.6, 0.7, and 0.8 decreases as the leachate % is increased. However, the value appears to be higher for the sample with 50% leachate, which contradicts with the other samples. This could be due to an experimental error. For the sample mixed with distilled water, the resistivity was found to be in the range of 40 to 80 (Ω m).

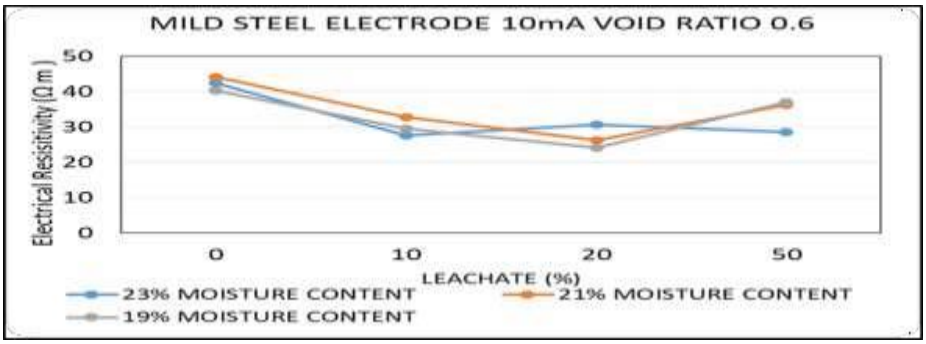

Fig. 5. Resistivity values for different percentage of leachate in soil samples of voids ratio 0.6

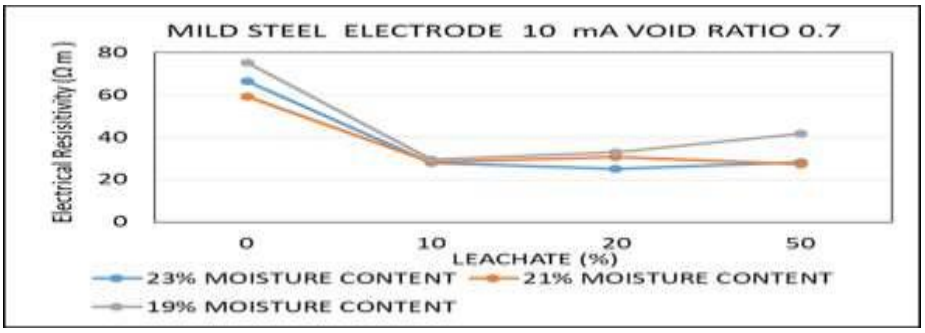

Fig. 6. Resistivity values for different percentage of leachate in soil samples of voids ratio 0.7

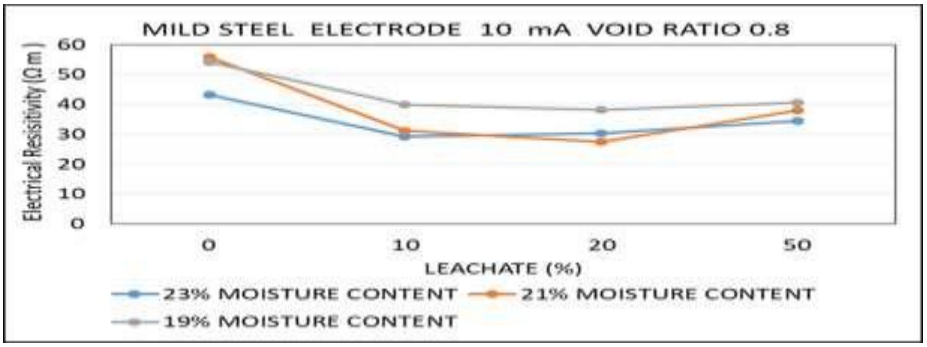

Fig. 7. Resistivity values for different percentage of leachate in soil samples of voids ratio 0.8

3.3 Calibration Charts

A calibration chart of these results can be created for this Turmuri site. This chart can be used for future tests conducted at this site. Using the calibration chart for different leachate percentages such as 0%, 10%, and 50%, one can indirectly determine the level of contamination using the electrical resistivity of the soil. As can be seen in Fig. 8, Fig. 9 and Fig. 10.

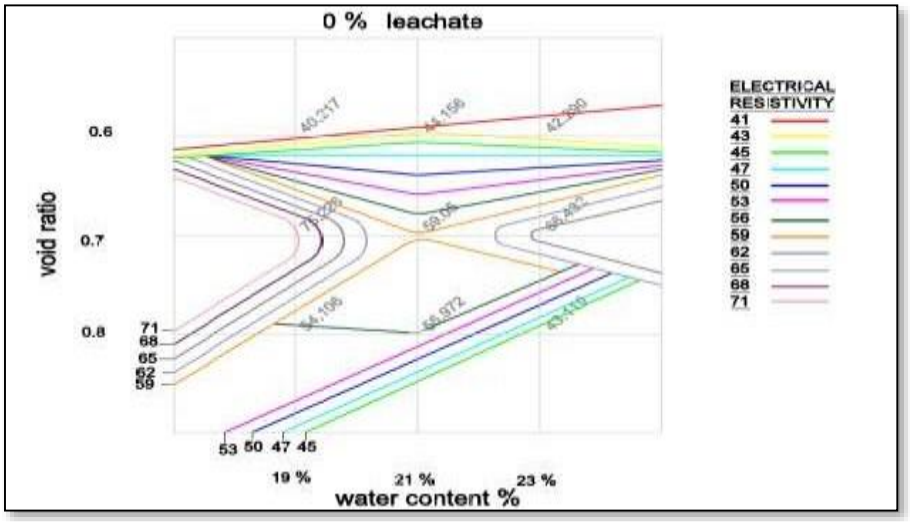

Fig. 8. Calibration Chart for 0% leachate content.

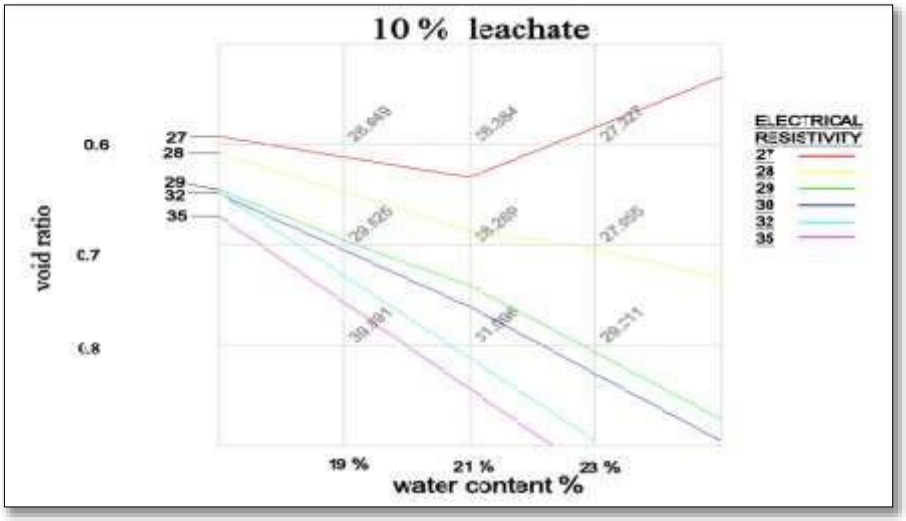

Fig. 9. Calibration Chart for 10% leachate content.

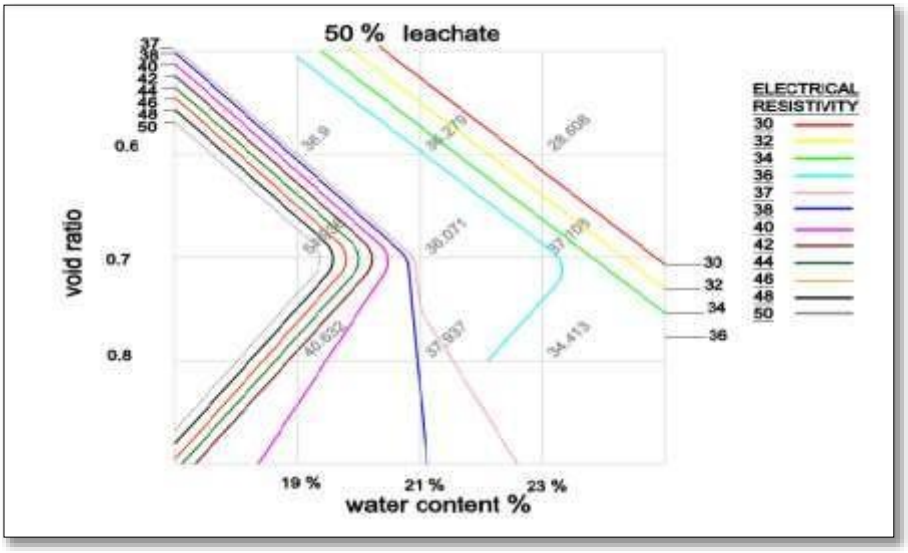

Fig. 10. Calibration Chart for 50% leachate content.

4 CONCLUSION AND SCOPE FOR FUTURE WORK

In this study, the correlations between the electrical resistivity of contaminated clayey sand, its moisture content, and the injected voltage values were investigated. Soil classification was performed on soil samples to determine soil properties. Distilled water and different concentrations of leachate were mixed with the soil at different void ratios. The apparent resistivity of the soil decreased while the amount of water-leachate mixture in the soil body increased. The filling of soil pores with the leachate solution and the formation of connecting bridges were found to be the main mechanism of current conduction in this case. The high moisture content and the presence of leachate as a pore fluid allowed the electric current to move freely to the electrodes

The final finding of this study concerned the value of the injected DC voltage in laboratory tests. The results showed that as the voltage increased, the curve of resistivity values versus moisture content showed less variation. It appears that the current at low voltages is very sensitive to the smallest changes in the continuity environment, including minimal conductivity within the sample.

Based on these results, a calibration chart can be created for the Turmuri site. This chart can be used for future tests conducted at this site. Using the calibration chart, one can indirectly determine the level of contamination using the electrical resistivity of the soil.

This study demonstrates the applicability of the electrical resistivity method for environmental monitoring of landfills, which, despite all the planning involved in their construction, may present failures particularly related to the containment of leachate. Such failures in leachate containment can be detectable by indirect research tools and noninvasive techniques, which can also help the development of precise and inexpensive system for punctual remediation in particularly complex conditions.

4.1 SCOPE FOR FUTURE WORK

a) A permeability test may be performed to determine the coefficient of permeability, to determine settlement issues, seepage, etc.
b) A detailed study of leachate chemical properties.
c) A field test may be performed to verify the calibration chart.

4.2 Limitations

The migration of pollutants emitted from the landfill to the soil-water environment, mainly depend on the mineralogical composition, moisture content, porosity, temperature, grain size distribution, or the chemical solution. These features significantly influence the resistivity of soil.

a) Duration of the time of measurement
The technical time of electrical resistivity acquisition has to be instantaneous compared to transport time
b) Calibration
Field prospecting using electrical resistivity can be associated with laboratory studies.
c) Contact between the soil and the electrodes
From the point of view of technical aspects, systematic errors due to poor electrode contact or noise averaging can be avoided by carrying out replicated and reciprocal (i.e. reversed the positive and negative current and potential electrodes).

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