



P-301

Environmental Study using Electrical Resistivity Imaging Tool [Syscal Kid Switch-24]

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Summary

The present study deals with resistivity variations with depth at three different locations in the K.U. Kurukshetra. Out of these, one survey was made in a plane area where there is variation in resistivity due to excess flow of water by flooding or irrigation in the past. In this case resistivity is low at a certain depth of 1.85-2.49m due to presence of moisture content. Another survey was near a canal which shows that how the seepage from a canal can lower the resistivity of nearby surrounding area. And the third survey was near a dump site. In the nearby area of this dump site the resistivity has been lowered due to the percolation of solid and liquid waste material. Like this human activities are very much affecting the variation in resistivity values of the subsurface.

Introduction

The purpose of electrical surveys is to determine the subsurface resistivity distribution by making measurements on the ground surface. Variation in resistance due to current flow at depth causes distinctive variations in the potential difference measurements which provide information about subsurface structure and materials. From these measurements, the true resistivity of the subsurface can be estimated. But, the ground resistivity is related to various geological parameters such as the mineral, fluid content, porosity and degree of water saturation in rock. The impact of pollutants like solid and liquid wastes produced by different sources (like domestic and different industries), pesticides used in agricultures on our environment can be studied by resistivity survey. Ground water contamination is increasing continuously by different types of pollutants. If somebody is disposing the solid and liquid waste at any site and that site is not suitable for the dump then it will affect our natural resources. So in this regard our main aim is to map or locate the site where we can dispose our solid and liquid waste so that their impact is less on our natural resources. The necessary condition for the dump site are: a) Dump site must be away from the fresh ground water aquifers b) There should be impermeable region or layer just below the dump site c) It must be away from our surface ground water bodies. Also we can locate the artificial ground water recharge by locating the region of

poorly sorted lithology where permeability is high or fracture zones in hard formations.

Electrical resistivity surveys have been used for many decades in hydrogeological, mining and geotechnical investigations. More recently, it has been used for environmental surveys.

Objectives

The main objective of this project is to measure the resistivity of the area at different locations and to know about:

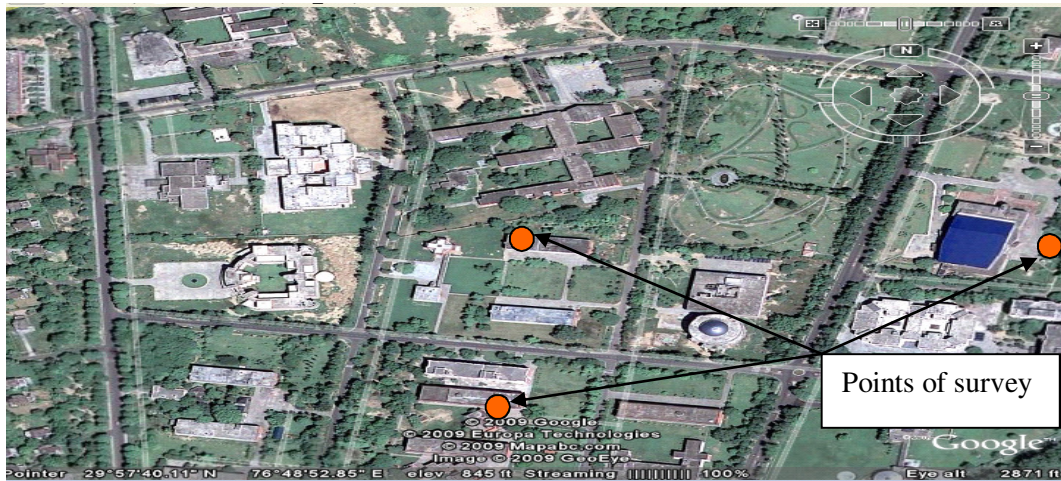
- What is the effect of watering and irrigation on the resistivity value of the surrounding area?
- How the resistivity of the nearby area is affected by a dump site.
- How the resistivity of an area is affected by the seepage from a canal.

Description of the area

The area of study is the campus of Kurukshetra University, Kurukshetra. This area is near the department of geophysics. The latitude, longitude and elevation of the area are 29.9615° N, 76.820° E and 845 feet respectively.



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Data base and methodology

Resistivity of a material is a fundamental physical property related to the ability of a material to conduct electricity. If R is the resistance of block of conductive material having length L and cross-sectional area A then resistivity is given as:

$$\rho = R \cdot A / L$$



Resistivity measurements of the ground are normally made by injecting current through two current electrodes and measuring the resulting voltage difference at two potential electrodes.

The resistivity determined with a four electrode configuration is the *true resistivity* of the half space. But in

real situations the resistivity is determined by different lithologies and geological structures and complexity will be taken into account. The result of such a measurement is the *apparent resistivity* of an inhomogeneous half space and generally does not represent the true resistivity of any part of the ground.

The apparent resistivity ρ_a is given by:

$$\rho_a = K \cdot V / I$$

Where v is voltage, ' I ' is current and k is the geometric factor which depends on the arrangement of the four electrodes. The k value can be calculated according to the formula:

$$K = 2\pi \left[\frac{1}{1/r_1 - 1/r_2 - 1/r_3 + 1/r_4} \right]$$

Where the subscripted r values are distances between the current and potential electrodes.

Thus the apparent resistivity is given as:

$$\rho_a = 2\pi \Delta V \cdot \left[\frac{1}{1/r_1 - 1/r_2 - 1/r_3 + 1/r_4} \right] / i$$

For quantitative interpretation, conventional sounding surveys were normally used. In this method, the centre point of the electrode array remains fixed, but the spacing



between the electrodes is increased to obtain more information about the deeper sections of the subsurface.

Based on the different type of electrode spacing the various configurations are:

1. Wenner
2. Schlumberger
3. Dipole-Dipole
4. Pole-Pole etc.

Out of these we used **Wenner** configuration. In Wenner electrode configuration the electrodes are uniformly spaced and the spacing is denoted by letter 'a'. In conducting and expanding spread Wenner survey all electrode are moved along a straight line after every reading such that spacing between electrodes remains equal. This configuration is generally use for profiling. The apparent resistivity ρ_a computed from measurements of voltage, ΔV , and current, I , is given by the equation:

$$\rho_a = 2\pi a \Delta V / I$$

Profiling and Sounding:

1. Vertical electrical sounding:

It is used mainly in the study of horizontal or near horizontal interface. The current and potential electrodes are maintained at the same relative spacing and whole spread is progressively expanded about a fix central point.

2. Constant separation traversing:

Also known as electrical profiling is used to determine lateral variation of resistivity. The current and potential electrodes are maintained at fixed separation and progressively moved along a profile.

2-D resistivity imaging method

The greatest limitation of the resistivity sounding method is that it does not take into account horizontal changes in the subsurface resistivity. A more accurate model of the subsurface is a two dimensional model where the resistivity changes in the vertical direction, as well as in the horizontal direction along the survey line.

This 2-D resistivity imaging method includes two steps:

a) Field survey method:

One of the developments in recent years is the use of 2-D electrical imaging/tomography surveys to map areas with moderately complex geology. Such surveys are usually carried out using a large number of electrodes, 25 or more, connected to a multi-core cable. A laptop microcomputer together with an electronic witching unit issued to automatically select the relevant four electrodes for each measurement. At present, field techniques and equipment to carry out 2-D resistivity surveys are fairly well developed. In 2-D survey number of electrodes along a straight line attached to a multi-core cable and constant spacing between adjacent electrodes is used. The multi-core cable is attached to electronic switching unit which is connected to a laptop computer. The sequence of measurements to take, the type of array to use and other survey parameter are normally entered into a text file which can be read by a computer program in a laptop computer. As an example, take a possible sequence of measurements with the Wenner array for a system with 20 electrodes and spacing between adjacent electrodes is 'a'. The first step is to make the all possible measurements with electrode spacing of '1a'. For a system with 20 electrodes there are 17 possible measurements with '1a' spacing for the Wenner array. After completing the sequence of measurements with '1a' spacing, the next sequence of measurement with '2a' electrodes spacing is made. There are 14 possible measurements with '2a' spacing. The same process is repeated for measurements with '3a', '4a', '5a' and '6a' spacing. Note that as the electrode spacing increases, the number of measurement decreases.

About electronic switching machine:

Syscal Kid Switch 24 resistivity imaging system for depths to 25m is being used. Designed for shallow ground water surveys, archaeological surveys and geologic mapping. The syscal kid is equipment designed for environmental applications. It is light weight, totally automatic and cost effective. It is an exploration tool, particularly adapted for shallow electrical surveys.

Its output characteristics are the following ones:

- 200V maximum output voltage
- 25W maximum output power
- 500mA maximum output current

The output voltage is chosen automatically in relation with the level of measured signal.

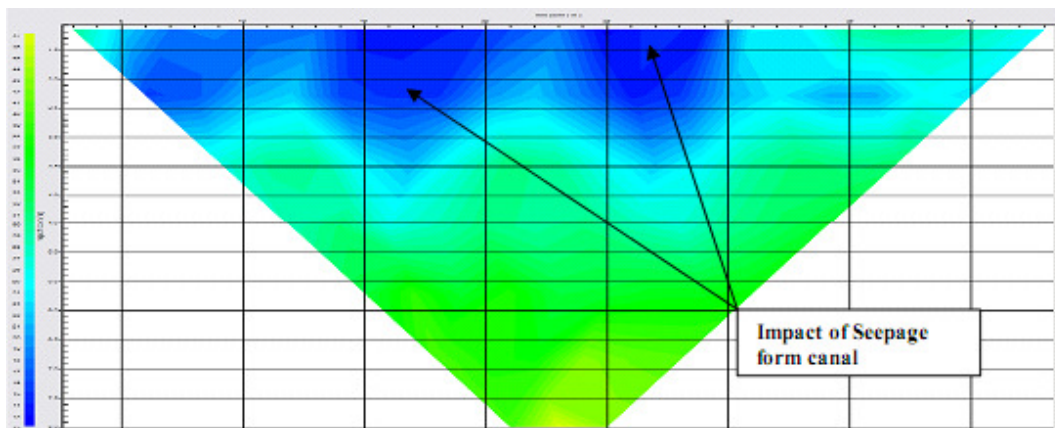


Syscal Kid SWITCH-24

apparent resistivity values in a pictorial form, and as an initial guide for further quantitative interpretation.

Case studies and result:

Using software named RES2DINV, we did inversion of this line after exporting the file for inversion from processing software PROSYS 11. Here we can see the inversion of section shown in Fig.1. This section shows the vertical as well as horizontal variation in resistivity values.



Pseudosection of resistivity data of canal side. Fig.1

b) Pseudosection data plotting method:

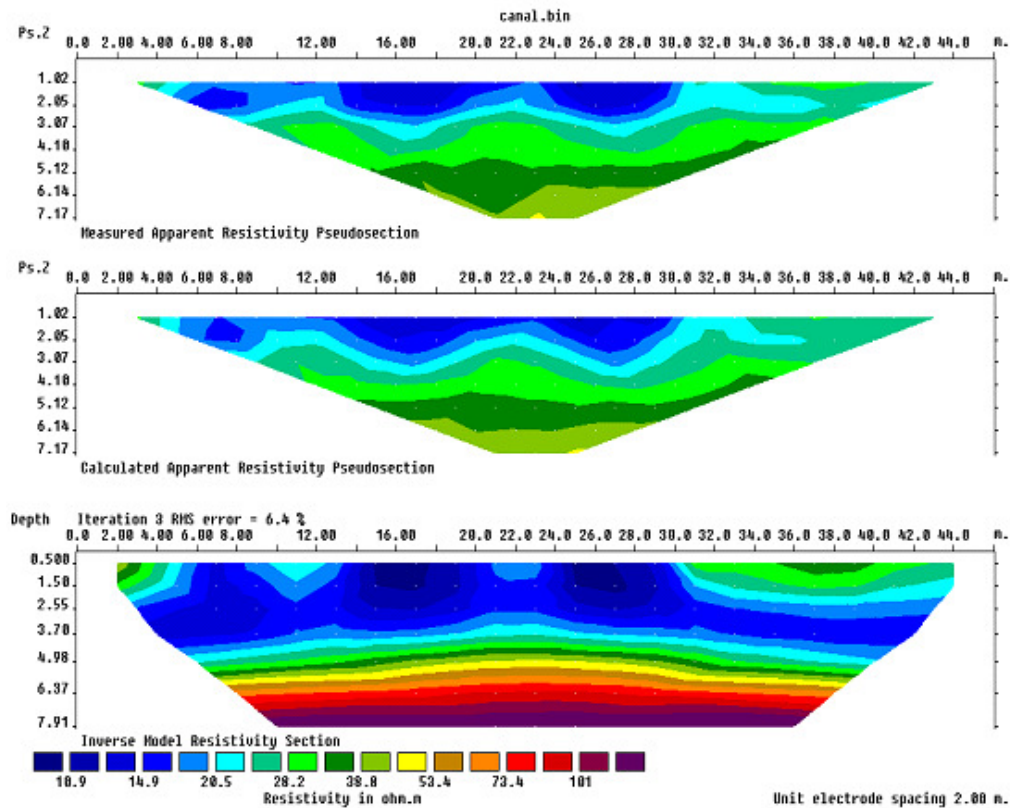
To plot the data from a 2-D imaging survey the pseudo section contouring method is normally used. In this case the horizontal location of the point is placed at the mid point of the set of electrodes used to make that measurement. The vertical location of the plotting point is placed at a distance which is proportional to the separation between the electrodes. One common method is to place the plotting point at the intersection of two resistivity distribution. The pseudo section is useful as a means to present the measured

Area near canal:

This geophysical survey was done to map the lithology of the soil materials near canal. In this case we took survey with a Wenner configuration using 2m spacing. Pseudosection of this point (Fig.1) shows the apparent resistivity along this section in a depth column of 1m to 8m. Resistivity of this area varies from 12.0 – 47.0 ohm-m. The resistivity values are very low near the surface and up to depth 4.0 m. This pseudo section shows how resistivity varies due to the presence of a canal in the nearby area.



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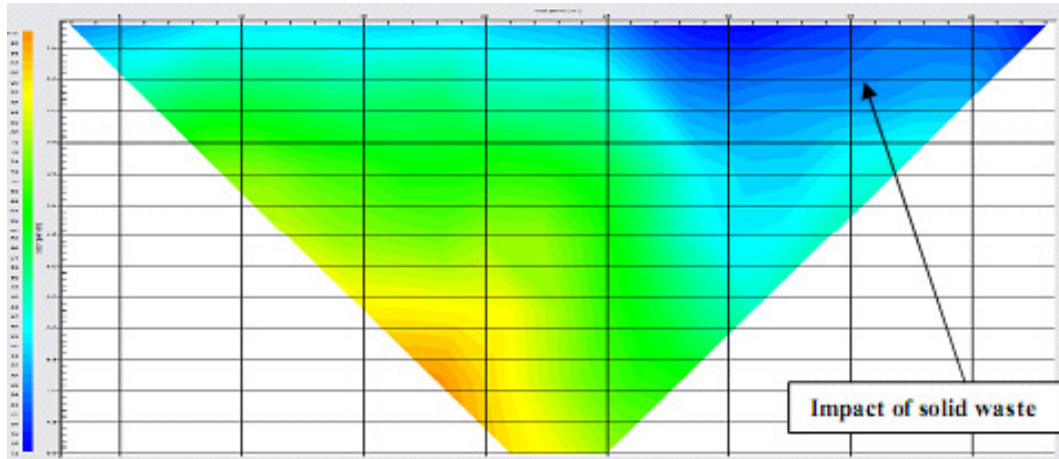


Inversion section of the data near canal. Fig.2

Here we observe that at the depth of 2.55-4.98 m resistivity is very less i.e. 10.9-14.9 ohm-m approximately which probably represents the presence of seepage from the canal thereby increasing the moisture content. This leads to the low values of the apparent resistivity.

Study of Dump site for solid waste near open theater:

In this area also we took our survey with the same spacing of 2m between the electrodes and used wenner configuration. Pseudosection of this area shows that resistivity values vary from 14.0 to 100.0 ohm-m resistivity. It is so high because of the dryness in the area and may also be because of the presence of the broken building material and boulders. At the same time there is presence of solid waste material. Due to the leaching of the contaminants and presence of moisture, the resistivity values are low in the range of 10.8 to 16.4 ohm m up to a depth of 0.5-1.5m.



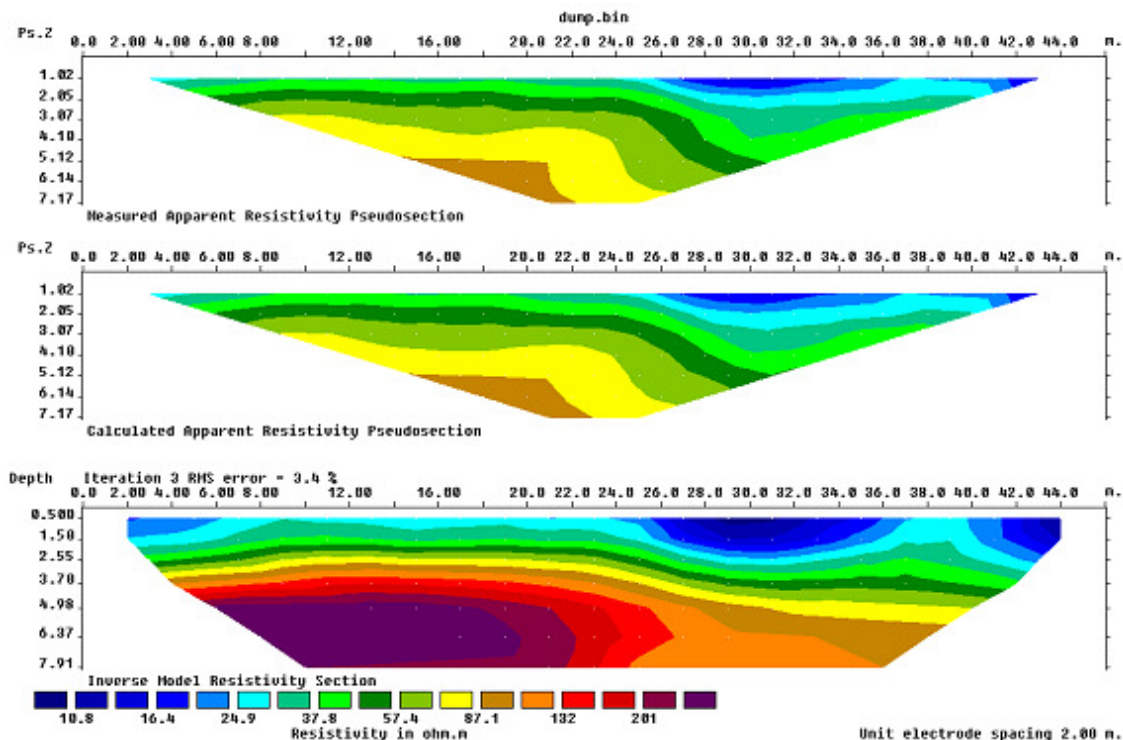
Pseudosection of the dump site area.Fig.3

Using another software named RES2DINV, we did inversion of this line after exporting the file for inversion from processing software PROSYS 11. Here we can see the inversion of section shown in Fig.3. In this section the resistivity values vary from 10.8-281.0 ohm-m. It shows the horizontal as well as vertical variation of resistivity values.

Here we observe that at the depth of 2.55-4.98m resistivity is very less i.e. 10.9-14.9 ohm-m approximately.



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Inversion section of the dump site area data. Fig.4

Conclusion

This study has provided valuable information regarding subsurface variation in terms of resistivity. As we used the instrument SYSCAL KID SWITCH-24 which is very interactive and easy to operate. This is also used for environmental analysis i.e. the effect of man's activities on environment. By using electrical resistivity imaging tool we can easily see that how resistivity values are affected by the presence of dump site and canal seepage. These observations will prove very useful in knowing the contaminant levels and their distribution in the subsurface. The presence of broken building material and the leakage of salts have also been observed at the observed sites.

Acknowledgements

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