

GEOPHYSICAL CHARACTERIZATION OF GOLF COURSE GREENS IRRIGATED WITH RECLAIMED WASTEWATER

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Introduction

The golf industry in the Spain has experienced extraordinary growth since 1950. In Spain, there are now over 300 golf courses and almost a quarter of a million licensed players, whereas 15 years ago, the number of golf players did not reach 30,000.

Nowadays, golf cannot be considered simply as a sport, because important economic interests are involved in it. In Catalonia, golf produces an economic impact of almost 20 million euro per year and the Tourism Authority of Catalonia proposed some time ago golf as a policy to promote special-interest tourism.

Golf course development has often generated controversy. In the recent years, there has been a considerable demand for golf courses to adopt environmentally sustainable strategies in design, construction, and management.

In spite of the application of geophysical techniques in the golf industry is unusual this paper is shown how geophysical methods can provide to golf course superintendents or greenkeepers a better understanding of the soil's properties influencing their turf. These properties not only affect the turfgrass but also influence other soil parameters, such as nutrient and pesticide leaching.

Methodology: Geophysics

The field portion of the near-surface geophysical research was carried out at Girona Golf Club (Catalonia, NE Spain) located about 100 km north to Barcelona city. The resistivity survey in the study area was conducted along 18 lines placed over each of the greens at the Girona Golf Club.

Data were acquired by a Syscal Pro resistivity meter using a mixed Wenner-Schlumberger configuration with electrodes 0.5 meter apart. Small stainless-steel nails were used as electrodes damage the fine turfgrass of greens. The resistivity meter was set for systematically and automatically selects current electrodes and measurement electrodes to sample apparent resistivity values.

The maximum investigation depth for this array was around 4.5 m enough for our purposes. A 2-D tomography inversion technique was employed to process the data using RES2DINV software. The method is based on the smoothness-constrained least-squares inversion of pseudo-section data. In this algorithm, the subsurface is divided into rectangular blocks of constant resistivity. Then the resistivity of each block is evaluated by minimizing the difference between observed and calculated pseudo-sections using an iterative scheme.

The smoothness-constraint leads the algorithm to yield a solution with smooth resistivity changes. Relative elevation change in the site is less than 1 m so topographical correction was not applied to resistivity data.

Methodology: Soil analysis

Particle size analysis (PSA) has been performed on soil materials of any putting green. The PSA analysis is composed of two distinct phases. One phase of the PSA is the textural analysis of a soil where the sand, silt, and clay contents are determined. Another phase of the PSA is the sand grain distribution analysis. The silt and clay content are determined using a pipette method. The sand grain distribution is determined via the use of a stack of sieves with decreasing sized openings from the top sieve to the bottom.

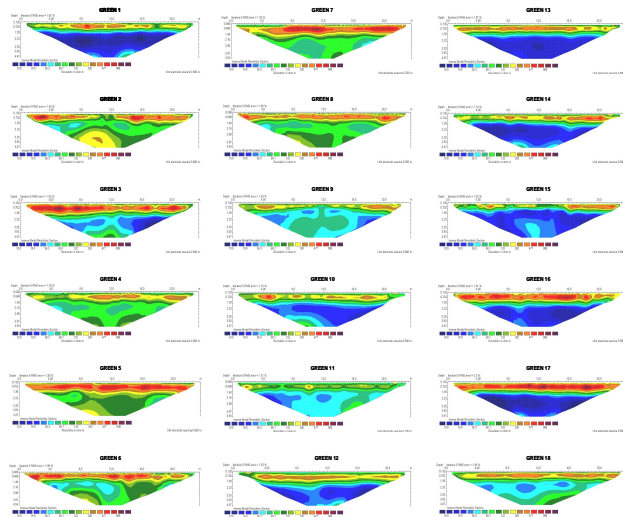
The electrical conductivity of soil samples was determined from the extract 1:5 and measured by a Crison microCM 2201 conductivity meter, with temperature probe and a standard conductivity cell constant of 1.1 cm⁻¹.

Finally the analysis of the organic carbon was determined using the Walkley-Black method.

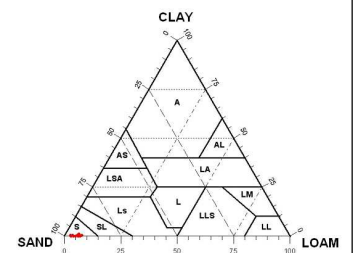
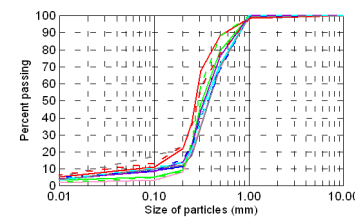


Results

INVERTED 2D ERT PROFILES



Every model has the same two layers structure with a high resistivity layer at top followed by a low resistivity layer. Nevertheless, the differences in thickness and resistivity values of the sandy top layer are quite evident. Also is shown that the resistivity of the low resistivity layer changes from hole to hole providing information about the lithology of the natural geological formation lying under the substrate of sand added for constructing the putting green.



The electrical resistivity of the upper layer changes from hole to hole and is highly correlated with soil texture derived from particle size analysis, providing information about the lithology of the natural geological formation lying under the substrate of sand added for constructing the putting green.

This information can be usefully applied for the hydrological and environmental management of the golf course.

Soil texture	Infiltration (mm/h)	Range (mm/h)	Flow rate (L/seg/ha)
Sand	50	25 - 250	140
Silty sand	25	15 - 75	70
Silt	12,5	8 - 20	35
Silty clay	8	2,5 - 15	22
Silty clay	5	1 - 15	14
Clay	2,5	0,03 - 5	7

Conclusions

1. This research has shown how the combined use of geophysics and soil analysis methods can be used for characterising soils and substrates of golf courses. Many golf courses use diagnostic core testing when making decisions concerning maintenance and renovation, nevertheless this procedure gives only point valuable insight in to the current condition of the turf system.
2. The results from our study indicate that electrical resistivity tomography method is an efficient tool which can be used by golf course greenkeepers to assess lateral and vertical variability of soils and substrates and prevent salinity hazard from irrigation with reclaimed wastewater.
3. The study has demonstrated that, although soil electrical resistivity depends simultaneously on many soil properties like moisture and salinity, the measurement of apparent resistivity in sandy substrates used for building putting greens can be easily correlated with his textural composition.

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RELATIONSHIP

