

Introduction

One of the most important characteristics of unsaturated soils is their water-retention behaviour. The soil water retention curve gives the relationship between *suction* and *degree of saturation* or *water content*. Existing techniques cannot accurately measure suction over the full range of potential values.

Suction = negative pore water pressure: $s = -u_w$

Degree of saturation: $S_r = \frac{V_w}{V_v}$

A novel experimental technique has been developed at Imperial College London, which allows the relative humidity inside sealed desiccators to be controlled and automatically regulated.

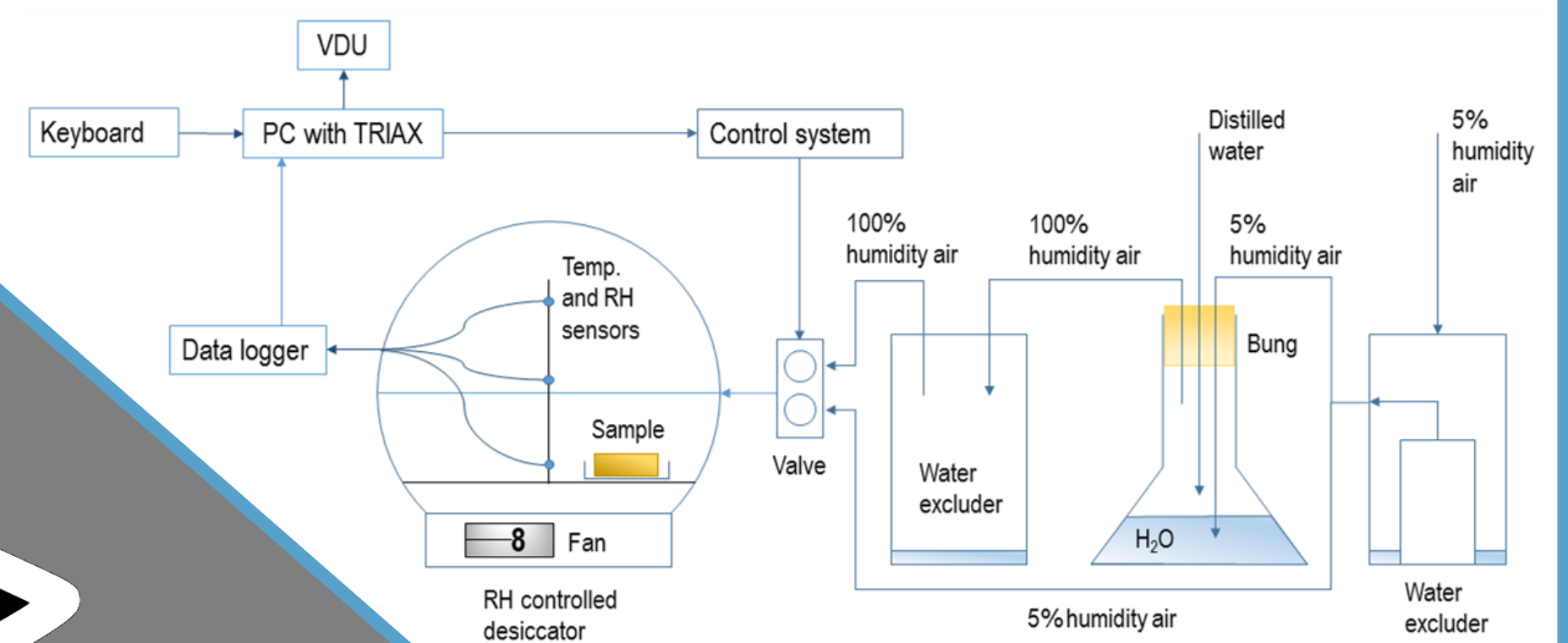
Tests were performed using London clay. A method of producing high-quality samples at low water contents was developed. The impact of factors such as compaction effort, sample size and initial water content was assessed. The research could have applications in the permanent storage/disposal of nuclear waste.

Experimental Methodology

The new technique involves mixing air at 5% or 100% relative humidity using a valve controlled by TRIAX software.

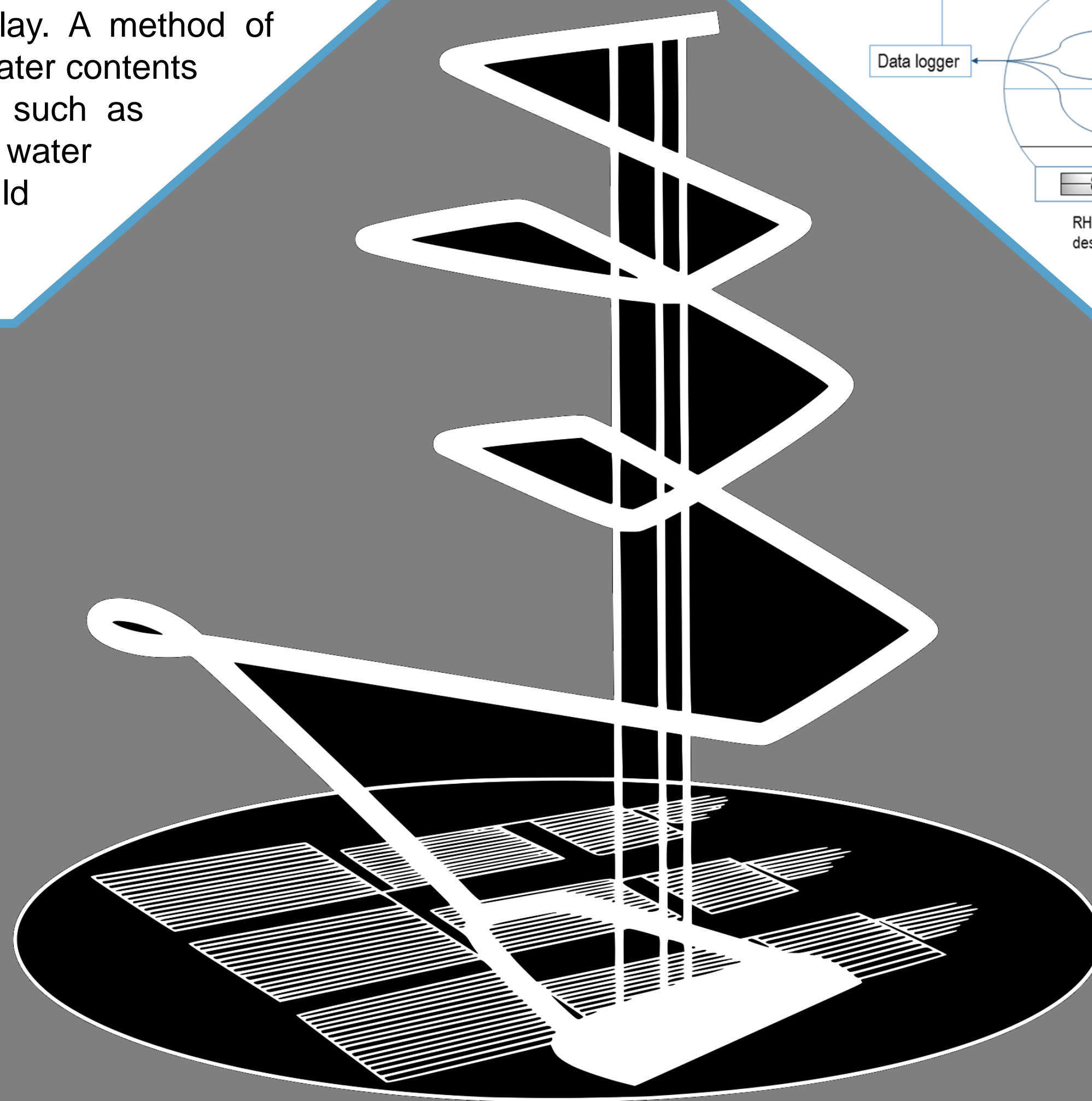
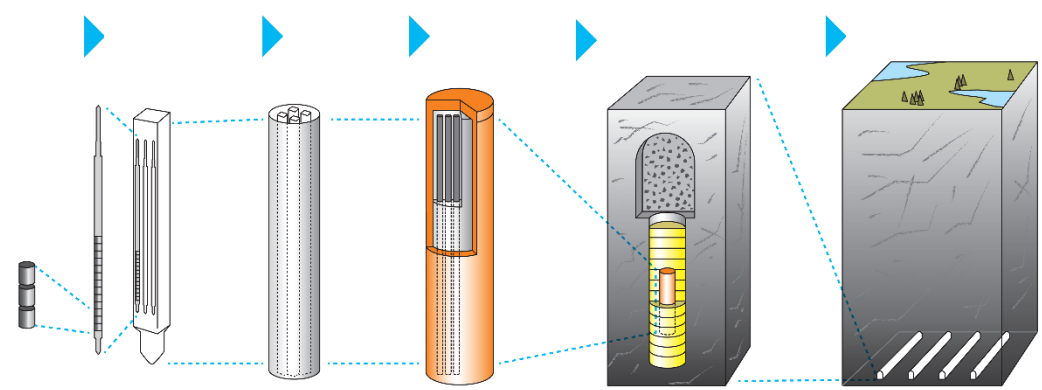
Relative humidity can be maintained at values between 80% and 10%, which corresponds to a suction range of 30 MPa to 300 MPa.

A data logger records temperature and relative humidity at regular intervals. The samples, which can be *free-swelling* or *fixed-volume*, are removed and weighed daily to determine their water content.



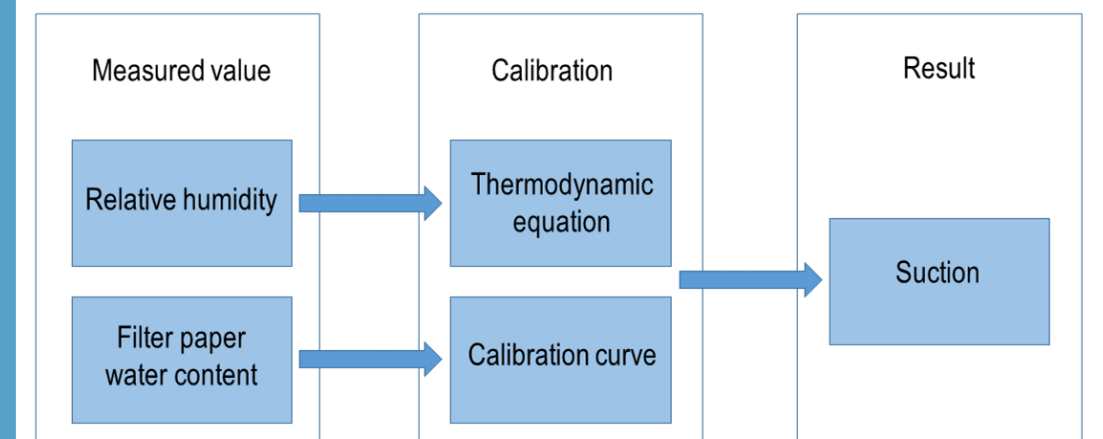
Deep geological disposal

Current proposals utilise the *multiple barriers* principle. One of these barriers will be a compacted bentonite clay buffer. Understanding the hydraulic behaviour of the buffer material is vitally important. This research forms a bridge to future studies using bentonite.



Suction measurement

The new method is an example of an indirect measurement technique. Based on a known value of *relative humidity*, the equivalent suction can be calculated using the *thermodynamic equation*. The filter paper method is also an indirect measurement technique.



Results

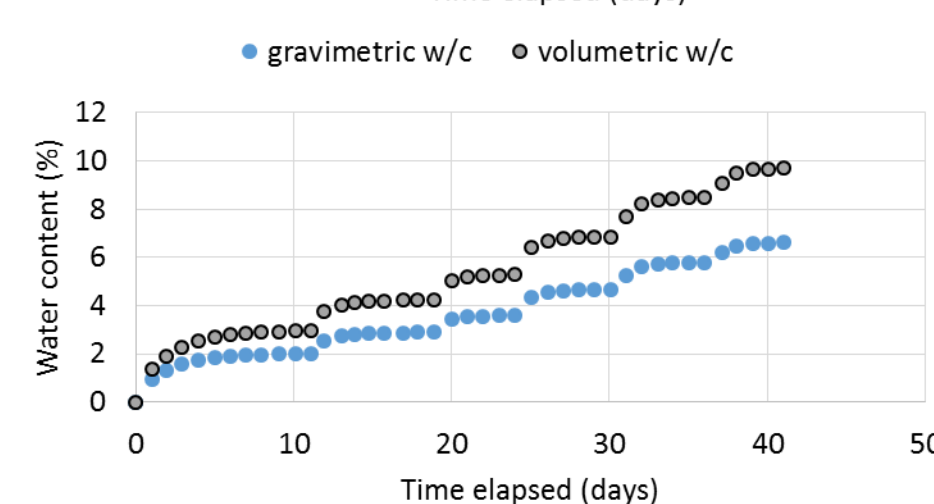
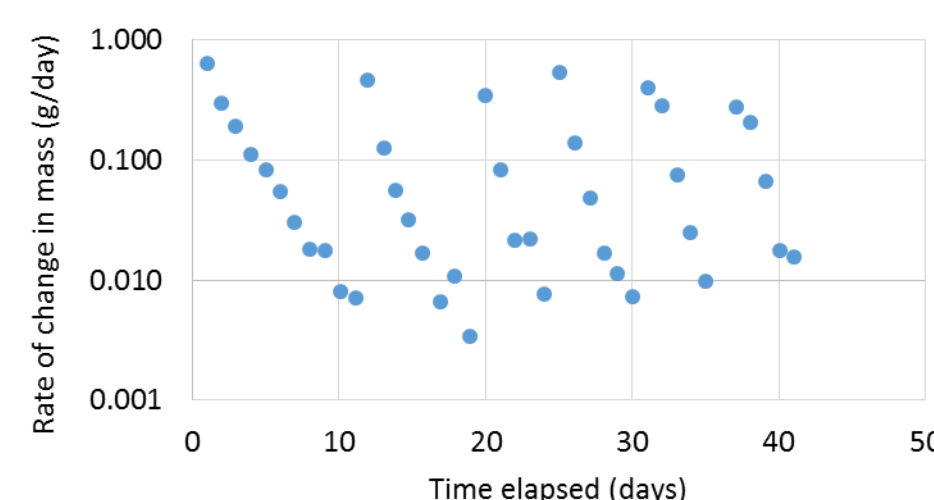
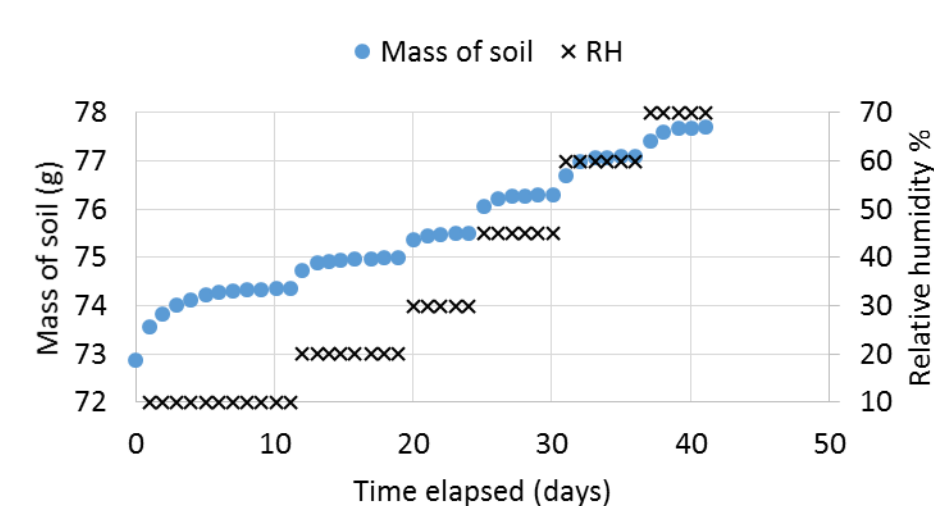
Each data point represents a daily mass measurement of one of the samples. From these values, the gravimetric (w) and volumetric (θ) water contents can be calculated.

$$w = \frac{m_w}{m_s}$$

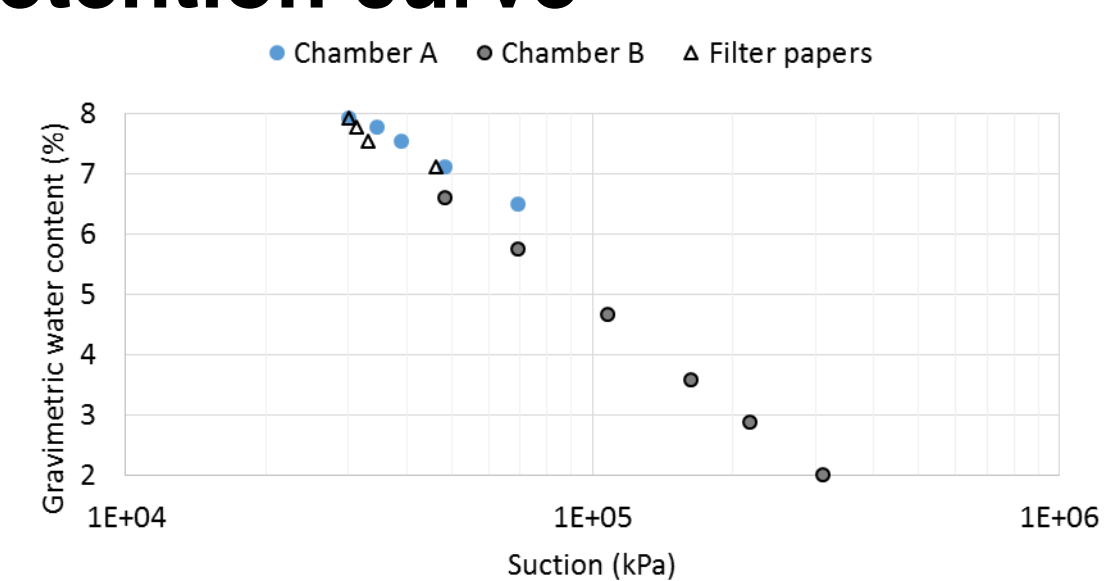
$$\theta = \frac{V_w}{V}$$

As the relative humidity is incrementally increased, the mass of soil increases. This is a result of the reduced suction applied to the soil, which causes it to absorb water.

When the water content of the soil becomes constant, it is said to be in equilibrium with its surroundings.



Soil water retention curve



A water retention curve was obtained using the novel experimental method. Results in the lower suction range were verified using the filter paper method. Data from the two chambers, representing different initial conditions, appeared to be converging at lower suction values.

Conclusion

The technique was found to be an effective method for determining soil water-retention behaviour. The new method reveals the equilibration behaviour of the soil, and can be used to accurately estimate equilibration time.

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References

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