The largest oil sands reserves in the world are located north of the city of Ft. McMurray, Alberta, Canada. The extraction of bitumen from the oil sands results in the production of large volumes of two types of tailings: sand tailings and fluid fine tailings (FFT). The FFT are a high-water-content mixture of water, soil, and residual hydrocarbons, which are pumped to large settling ponds. After initial sedimentation, the larger particles settle to the bottom, leaving a thick slurry layer known as mature fine tailings (MFT) (Fig. 1). These MFT deposits could take hundreds of years to consolidate sufficiently to enable final reclamation and closure. As a result, the industry is using a wide variety of methods to accelerate the consolidation process. The primary indicator of the success of these approaches is the direct measurement of bulk density, water content, or solid percentage of the MFT with depth and over time. Therefore, the development of a rapid, automated, inexpensive, and non-radioactive method to evaluate MFT consolidation is of value.

In a new study published in the January–February 2015 issue of the *Journal of Environmental Quality*, researchers from the University of Saskatchewan evaluated the feasibility of a dual-probe heat pulse (DPHP) method to measure MFT solid percentage. The DPHP method has been widely used to measure soil thermal properties. A dual probe has two needles: a heater needle to release a short pulse of heat into soil and a sensor needle to measure the temperature response of the soil. The heat capacity of soil can be derived by the temperature response information, which varies with soil bulk density and soil water content. In the field, the bulk density of a soil is relatively constant, so the change of heat capacity is mainly controlled by changes in soil water content. Based on this fact, the DPHP method has been used to measure soil water content. However, MFT differs from a normal field soil in two ways. First, both the bulk density and water content of MFT can change over a large range during consolidation. Second, MFT will always remain as a slurry in which the fluid phase, rather than the solid phase, is the larger proportion of the total soil volume. Little is known about the performance of the DPHP method in these types of media.

The authors derived mathematical equations to calculate the solid percentage of MFT. The solid percentages of 12 samples were measured by the DPHP method, and the results were compared with those from the standard method: oven-drying. Their results show that there was a good linear relationship between two methods. An additional six MFT samples collected from different depths (ranging from 8 to 45 m) within an existing MFT deposit were then tested to validate the test method. These results highlight that the DPHP method provides a precise and accurate measurement of MFT solid percentage. However, to estimate the MFT solid percentage by the DPHP method, the specific heat of the MFT solids must be known. This property can either be assumed (based on typical mineral values) or can be measured independently. The authors applied an improved modulated differential scanning calorimetry method to obtain independent measurements of the specific heat of the MFT dry solids. Perturbation analysis shows that independent measurement of specific heat of MFT solids was not necessary to obtain accurate measurements of MFT solid percentage in situ.

This authors say that this method is accurate, inexpensive, automated, and can be easily adapted to monitor the solid percentage changes of MFT in the oil sand tailing ponds. Multiple dual probes can be installed at different depths and locations in MFT ponds for determining both the thermal properties and solid percentage during the MFT solidification process.

Adapted from Min, L., S.L. Barbour, and B.C. Si. 2015. Measuring solid percentage of oil sands mature fine tailings using the dual probe heat pulse method. J. Environ. Qual. 44:293–298. View the full article online at http://dx.doi.org/doi:10.2134/jeq2014.06.0262