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ESTIMATING HYDRAULIC PROPERTIES OF WASTE STORING FACILITY FINAL COVER SYSTEM USING FIELD-SCALE SENSOR SYSTEMS

The process of temperature and water content specific calibration of the TDR sensors was considered to develop a highly-representative field data for water balance simulations of the unsaturated flow in final cover system using UNSAT-H and RZWQM2 models.
Keywords: **hydraulic properties, final cover, waste storing facility, sensor systems.**

Today the problems of water management and environment recovery have become not only of national but also of international significance. Water capacity potential of any territory is a basis for its economic development, social and environmental well-being [1].

Land disposal of waste, as a method that has potential risk to pollute or degrade its environment, has been and continues to be the most widely-used form for waste management.

On the contrary to an open dump, modern engineered landfills are expected to control fire and spread of litter, limit contact wildlife, minimize or eliminate the release of mobile contaminants to the surrounding environment, and provide acceptable end-of-service land use. From the perspective of environmental protection, release of contaminants to air and groundwater is often considered the most significant issue. If such release occurs, the toxic chemical compounds in various states of aggregation set conditions for air, soil, water bodies and groundwater pollution [2]. To avoid such negative influences, the careful siting and proper design of landfill is required. This can be achieved by construction of an envelope that consists of a top cover and bottom liner that encapsulate the waste and prevent escape of leachate into the environment.

Thus, modern well-constructed landfill is an engineering structure that consists of a composite liner system, leachate collection and removal system, gas collection and control system, and final cover system. Final cover systems are usually multilayered and provide multiple functions, main among those are keeping out infiltration and keeping gases and volatile components in the waste [3].

On the contrary to conventional final covers, alternative earthen covers generally use unique characteristics of unsaturated flow, the storage capacity of fine-grained soils and moisture-evaporation ability of plants to regulate the cover water-balance elements and thus minimize percolation as a potential leachate. Earthen covers employing capillary or monolayer barrier principle can be effective in minimizing percolation into underlying waste in semiarid and arid regions [4, 5]. They can be constructed in various forms, ranging from a simple design consisting of two layers or more complex designs that include multiple layers of soils with different hydraulic properties.

The key objective of this numerical and field study is to estimate the unsaturated hydraulic properties of an earthen cover that has been in service for over 5 years. The instrumented field cover is located near Omaha, Nebraska (USA) where the soil is expected to undergo freeze /thaw and wetting /drying cycles. These cyclic seasonal stresses are expected to change the hydraulic properties and hence the hydrologic performance of the cover [6].

Field Instrumentation. The data was obtained from field-scale sensor systems that measure soil volumetric water content, matric potential and in-situ meteorological characteristics.

Sensor pits, about 18 in wide × 8 ft long × 7 ft deep were dug on the site. The 1st pit was dug on the flatter portion of the test section and the second pit was dug on the steeper portion of test section. Now onwards, the east side nest or pit will be referred to as "A" and the west side pit or nest will be referred to as "B" (Fig. 1).

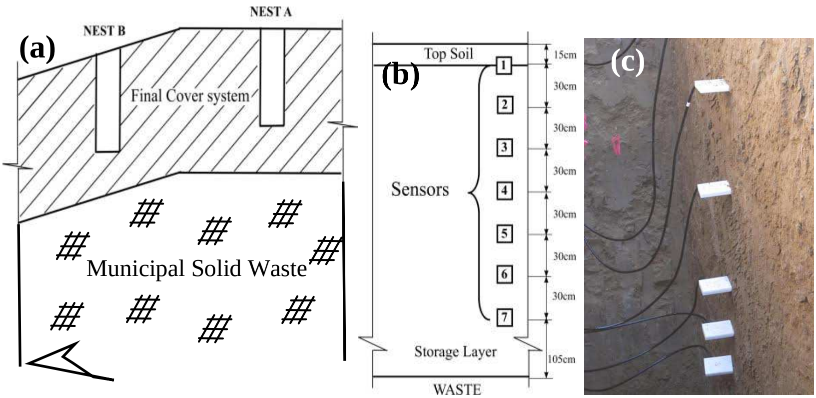

Fig. 1. (a) Nests location in the final cover system, (b) cross-section of the nest with sensors and (c) in-situ installation of sensors

Matric suction was measured using Heat Dissipation Matric Potential (HDMP) sensors (Fig. 2.) which are thermocouple psychrometers [7].

Fig. 2. HDMP sensor

During operation, the difference in temperature between the “wet bulb” (junction of thermocouple exposed to the soil atmosphere) and the insulated junction serving as a “dry bulb” generates an electromotive force, which is indicative of the soil moisture potential.

Volumetric water content (VWC) was measured with CS 616 sensors (Fig. 3) using Time-Domain Reflectometry (TDR) method [8], which is based on the differences in dielectric constants of water and soil.

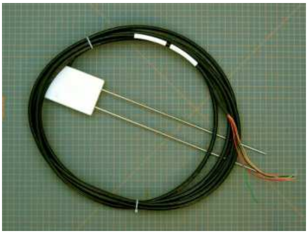

Fig. 3. CS 616 TDR sensor

During the sensor operation, its rods serve as conductors, while the soil between and around them – as a dielectric medium. When a step voltage pulse is propagated along the parallel transmission lines (rods), the signal is reflected from the ends of those rods and returns to the receiver, which measures the time intervals between pulses, which is indicative of moisture in the soil (time interval increases with soil wetness).

The group of sensors was installed in the A nest: 7 TDR616 and 7 HDMP. The soil was relatively dry with gradual visible increase in water contents at deeper depth. The TDR sensors were installed using holes made by grooving tool supplied by Campbell Scientific. The grooving tool was inserted inside the TDR spacer tool to maintain correct distance and alignment of the two holes to insert the sensor rods.

The same way, 7 TDR616 and 7 HDMP sensors were installed in the B nest. The soil was relatively moist to wet. The TDR sensors were installed without the use of the grooving tool. The TDR spacer tool was used and the sensor rods were pushed into the wall of the pit.

The ID's assigned to the sensors are as follows:

- A Nest: A1 to A7 (6, 18, 30, 42, 54, 60 and 66 inches below ground surface, respectively); and
- B Nest: B1 to B7 (6, 18, 30, 42, 54, 60 and 66 inches below ground surface, respectively) (see Fig. 1).

All sensor cables were enclosed in a 3 in dia. PVC conduit laid about 6 in below the ground surface in the east-west direction.

Water Content Sensors Calibration. The signal *propagation time* along the rod of TDR sensor is sensitive to the change in surrounding temperature. In addition, the magnitude of the temperature sensitivity also changes with soil *water content*. Thus, the TDR sensor specific calibration is required, taking into account three variables: VWC, propagation time and temperature.

The laboratory measurements were performed at various water contents (range from 0.06 cm^3/cm^3 to 0.41 cm^3/cm^3) and over the temperature (range from 5°C to 40°C) to derive a surface fit of VWC correction based on temperature and propagation time (Fig. 4). The temperature correction assumes that both the water content and temperature do not vary over the length of the probes rods.

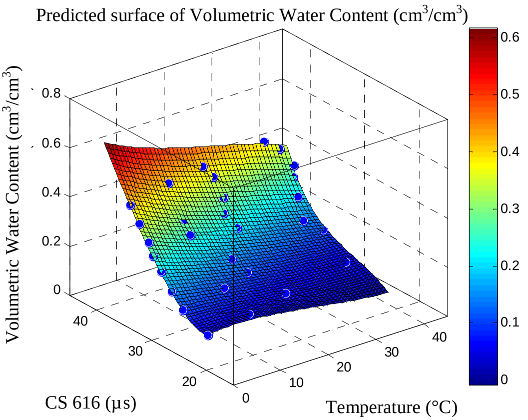

Fig. 4. Temperature effect on measurement of VWC with CS616 TDR sensor

The error in measured VWC over the year in Nest A, caused by the temperature dependence of the CS616 is shown in Figure 5.

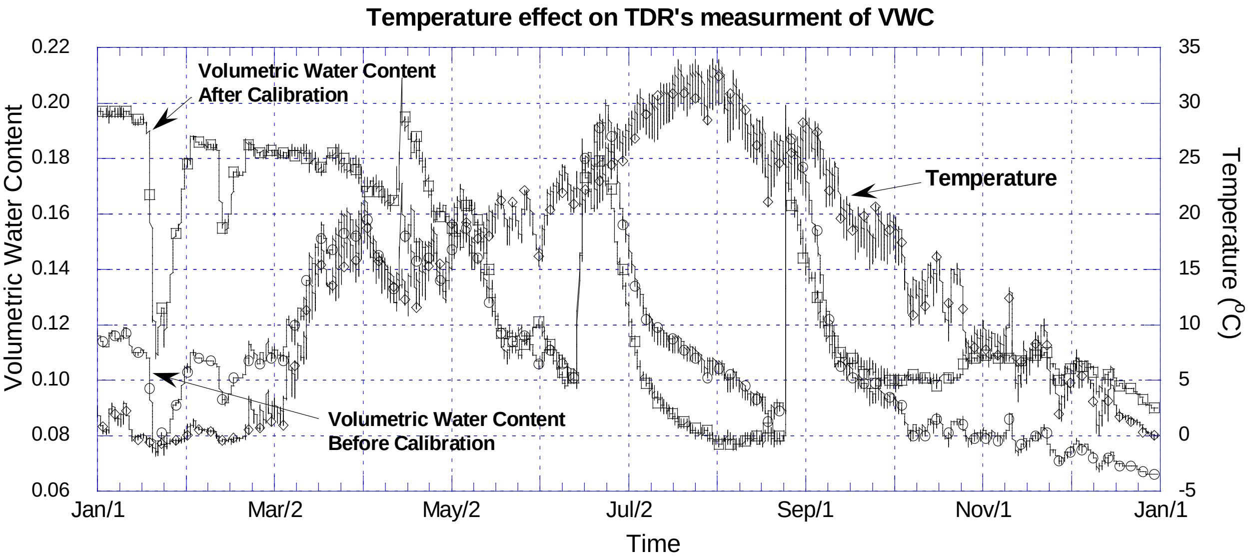

Fig. 5. Temperature effect on measurement of VWC with CS616 TDR sensor

Thus, measurement of field hydraulic properties is highly recommended as they have major influence on earthen final cover water balance elements. Temperature specific calibration of the water content sensors is critical to accurately measure field water contents.

If room temperature (20°C) is used during the calibration process, measured water contents will be less than the true water contents when the ambient temperature is lower than 20°C ("cold" period) and higher when the ambient temperature is more than 20°C ("hot" period of the year).

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ВИЗНАЧЕННЯ ВОДНО-ФІЗИЧНИХ ХАРАКТЕРИСТИК РЕКУЛЬТИВАЦІЙНОГО ШАРУ ОБ'ЄКТА СКЛАДУВАННЯ ВІДХОДІВ НА ОСНОВІ ВИКОРИСТАННЯ ПОЛЬОВИХ СЕНСОРНИХ СИСТЕМ

Розглянуто процес калібрування TDR сенсорів для отримання даних польових досліджень з високою репрезентативністю та їх по-

дальшого використання для водобалансових розрахунків рекультиваційного шару на основі використання моделей UNSAT-H та RZWQM2.
Ключові слова: **водно-фізичні властивості, рекультиваційний шар, об'єкт складування відходів, сенсорні системи.**

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ОПРЕДЕЛЕНИЕ ВОДНО-ФИЗИЧЕСКИХ ХАРАКТЕРИСТИК РЕКУЛЬТИВАЦИОННОГО СЛОЯ ОБЪЕКТА СКЛАДИРОВАНИЯ ОТХОДОВ НА ОСНОВЕ ИСПОЛЬЗОВАНИЯ ПОЛЕВЫХ СЕНСОРНЫХ СИСТЕМ

Рассмотрен процесс калибрования TDR сенсоров для получения данных полевых исследований с высокой репрезентативностью и их дальнейшего использования для водобалансовых расчетов рекультивационного слоя на основе использования моделей UNSAT-H и RZWQM2.
Ключевые слова: **водно-физические свойства, рекультивационный слой, объект складирования отходов, сенсорные системы.**
