

Biobed Temperature and Moisture Trends of a Manitoba Biobed During Operational Period and Comparison of Probe Types

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Introduction

A new two-celled biobed has become operational at the Ian Morrison Research Farm in Carman, MB (Fig. 1). Biobeds are a bioremediation system aimed at reducing pesticide contamination risk. Biobeds vary in design but are generally a pit or container containing a biomixture that retains and degrades pesticides. This biomixture is usually comprised of dry plant material (e.g. straw, wood chips), humified organic matter (e.g. peat, compost), and soil. Biomixture temperature and moisture affect the binding and degradation capabilities of the biobed. Since these are important factors in biobed function, two types of probes, the Sentek Drill and Drop probe and the Hydra-probe, were installed in the Carman biobed for monitoring biobed moisture and temperature (Fig. 2). In this study we compare the moisture and temperature measurements between probe types, depth, and between biobed cells during the operational period.

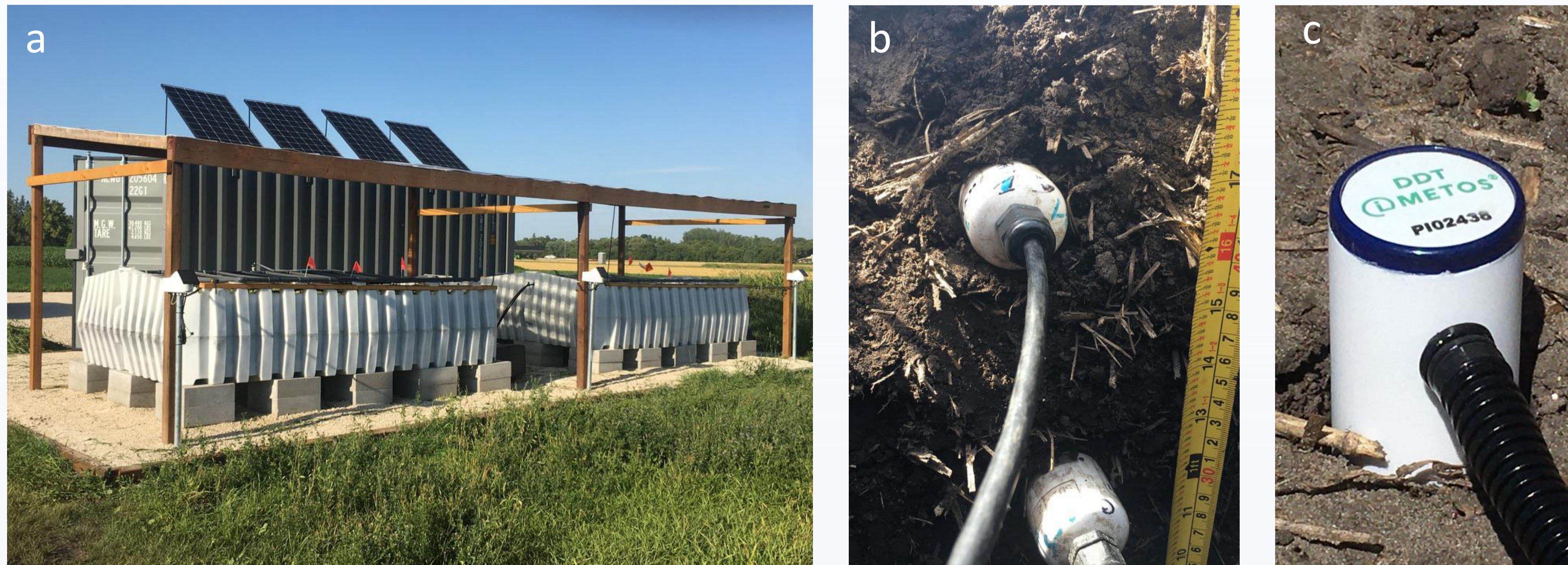


Fig. 1. Pictures of biobed site in Carman (a), Hydra-probe (b), and Sentek probe (c).

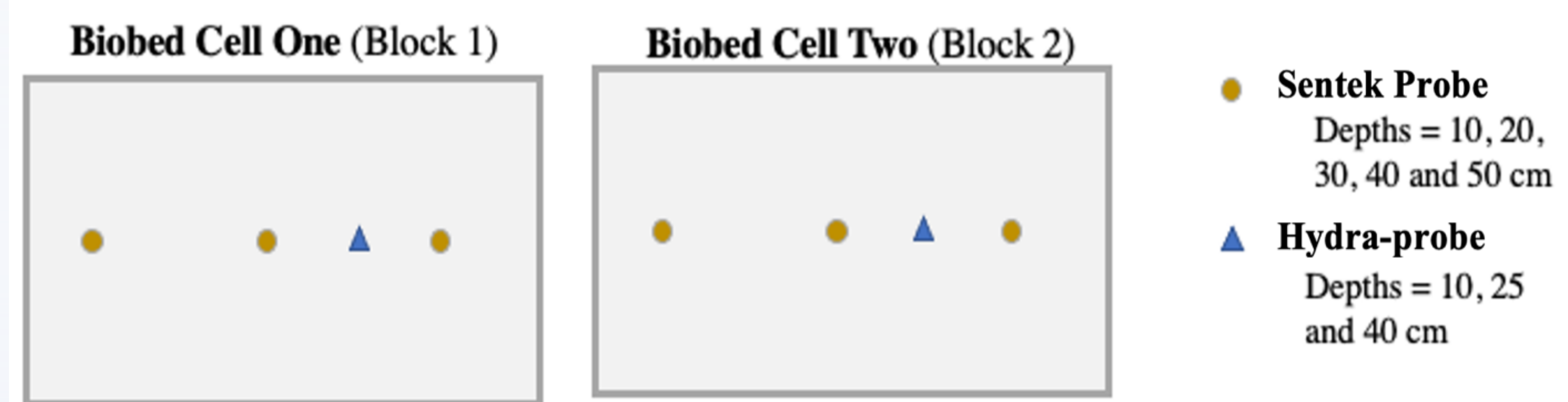


Fig. 2. Probe locations of Sentek and Hydra probes in biobed cells

Experimental Design

The experiment was designed as a randomized complete block with the blocking factor and experimental unit being the biobed cell. A one-way treatment structure was used for the probe type factor with depth as a repeated measures factor. Probe measurements were recorded hourly for each probe type and depth during the operational period of the biobed.

Materials and Methods

Three Sentek probes that have sensors every 10 cm were installed into each biobed cell to measure volumetric water content, and temperature at five depths (Fig. 2). In addition, three Hydra probes that have single sensors were installed at one location in each of the biobed cells, but at three depths (Fig. 1). The Hydra-probes measure water fraction by volume (wfv) and temperature. Biomixture moisture contents measured with the Sentek probes were converted from volumetric water content to wfv in order to make the comparison with the Hydra probes. Sentek and Hydra probes were compared using data from 10 and 40 cm depths.

Statistical Analysis

A beta distribution was used for the moisture content data and a normal distribution with equal variances was used for temperature data. Analysis of variance was conducted for several scenarios using PROC GLIMMIX in SAS ver. 9.4 (SAS Institute Inc. 2013). Treatment mean pair-wise comparisons were performed using Tukey's Method with an alpha of 0.05. The ILINK function was used to back transform soil moisture data from the logit values to the original units.

Results and Discussion

Across probe type and depth, biomixture moisture contents ranged from 0.1348 to 0.3180 on a wfv basis, while biomixture temperatures ranged from 14.95 to 15.90 °C. The biomatrix moisture content significantly increased in the order of 10 < 20 < 30 < 40 < 50 cm (Table 1) for Sentek probe measurements. The surface layers were dryer than deeper depths due to the influence of water drainage to depth, and evaporation near the surface. The biomatrix temperature was relatively consistent with depth except that there were significantly lower temperatures at 10 cm than other depths, and that the temperature was significantly lower at 20 cm than 50 cm depth.

Table 1: Effect of depth on biomixture moisture content and temperature taking into consideration all data from Sentek probes installed in biobed cell one and two.

Effect	Biomixture Moisture (wfv)	Biomixture Temperature (°C)
Probe Depth		
10 cm	0.05879e	14.59a
20 cm	0.1678d	15.20b
30 cm	0.2475c	15.17bc
40 cm	0.3015b	15.30bc
50 cm	0.3871a	15.37c
P-value	<.0001	<.0001

Table 3: Effects of biobed cell on moisture content and temperature taking into consideration the 10 and 40 cm data from the Sentek and Hydra probes.

Effect	Soil Moisture (wfv)	Soil Temperature (°C)
Biobed Cell		
One	0.2452a	15.27a
Two	0.1635b	14.97b
P-value	<.0001	<.0001

Table 2: Effects of probe type and depth on moisture content and temperature taking into consideration the 10 and 40 cm data from the Sentek and Hydra probes. Significant interactions for moisture content data are explained in Figure 3.

Effect	Biomixture Moisture (wfv)	Biomixture Temperature (°C)
Probe Type		
Hydra-Probe	0.3085	15.90a
Sentek	0.1401	14.95b
Probe Depth		
10 cm	0.1348	15.09a
40 cm	0.3180	15.76b
P-value		
Probe Type (T)	<.0001	<.0001
Probe Depth (D)	<.0001	<.0001
T x D	<.0001	0.5812

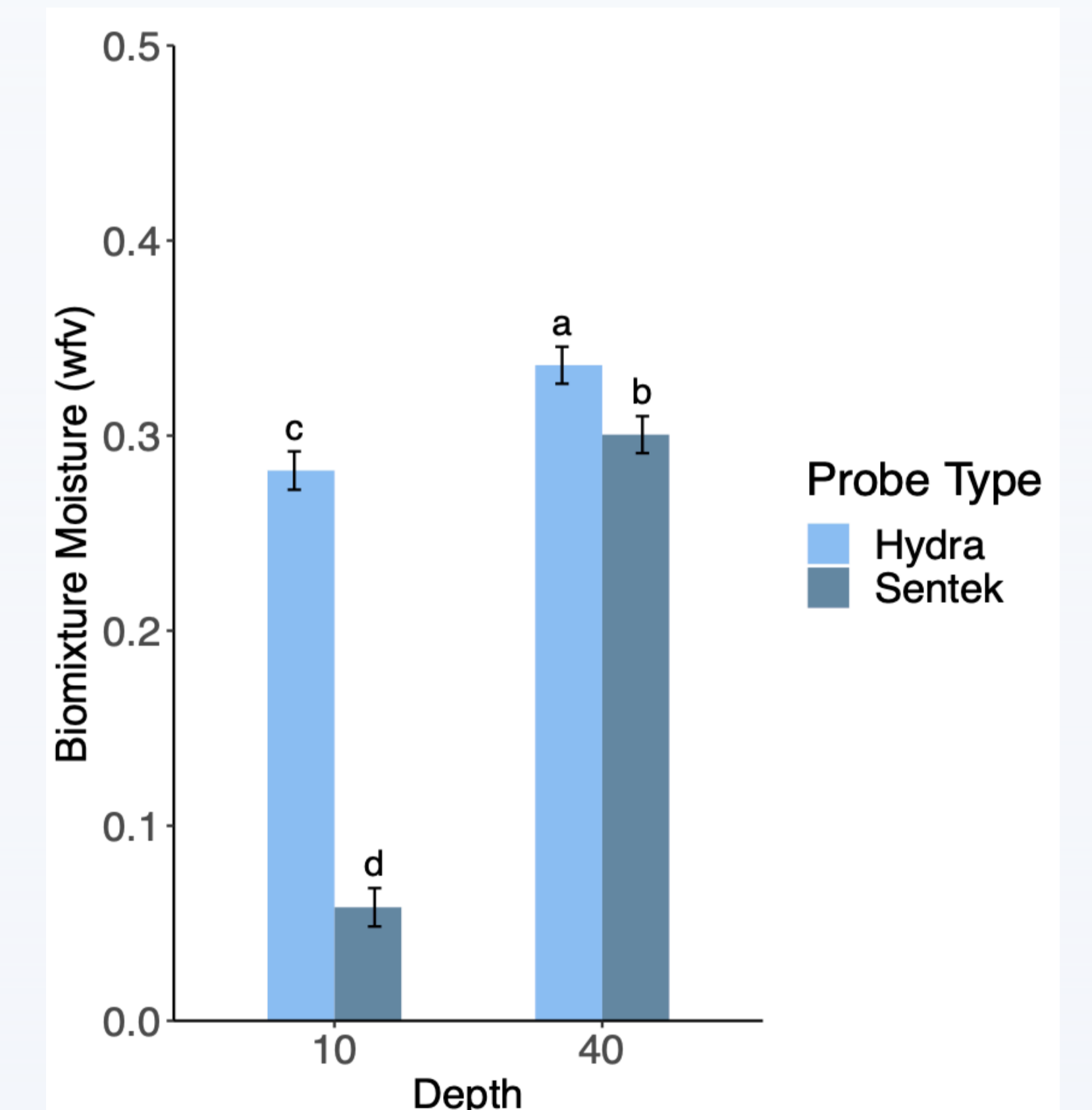


Fig. 3: Significant interactions of the effects soil probe type and depth on moisture content. Error bars show the standard error. Different letters indicate significant differences at $P < 0.05$.

Both biomixture moisture contents and temperatures significantly differed between probe types and among probe depths (Table 2), but for moisture content, the interaction between probe type and depth was significant as well (Figure 3). Specifically, the moisture content significantly increased in the order of Sentek at 10 cm < Hydra at 10 cm < Sentek at 40 cm < Hydra at 40 cm. As well, biobed cell one had a significant larger moisture content than biobed cell two (Table 3) because of the decreased volume of rinsate applied to the second biobed cell compared to the first biobed cell. Biobed one also had a significantly larger temperature than biobed cell two (Table 3) perhaps because its greater moisture content reduced the temperature fluctuations between day- and night-time, relative to the dryer second cell.

Conclusion

When two-cell biobeds are in operation, biobed cell one is likely to be wetter and warmer than biobed cell two, therefore cells might show different pesticide retention and degradation rates, as well as different microbial communities over time. Temperature and moisture content depended on the type of probe used and their depth location in biobeds. Field calibrations need to be performed to evaluate which probe type produces more accurate results in this artificial biomixture.