

Modeling Diurnal Fluctuations in Water Content for Surface-Applied Broiler Litter



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INTRODUCTION

Typical application rates of broiler litter to pasture average 5,000 kg ha⁻¹ which results in a 2 to 4-mm depth of litter on the surface primed to interact with atmospheric conditions. Broiler litter at typical water content (WC) has a very low water potential (WP), -30 MPa at 0.25 g H₂O g⁻¹, which under high relative humidity (RH) results in a large water potential (WP) gradient between litter and atmosphere. Changes in RH near the soil surface may lead to fluctuating litter water content, N mineralization, and ammonia volatilization.

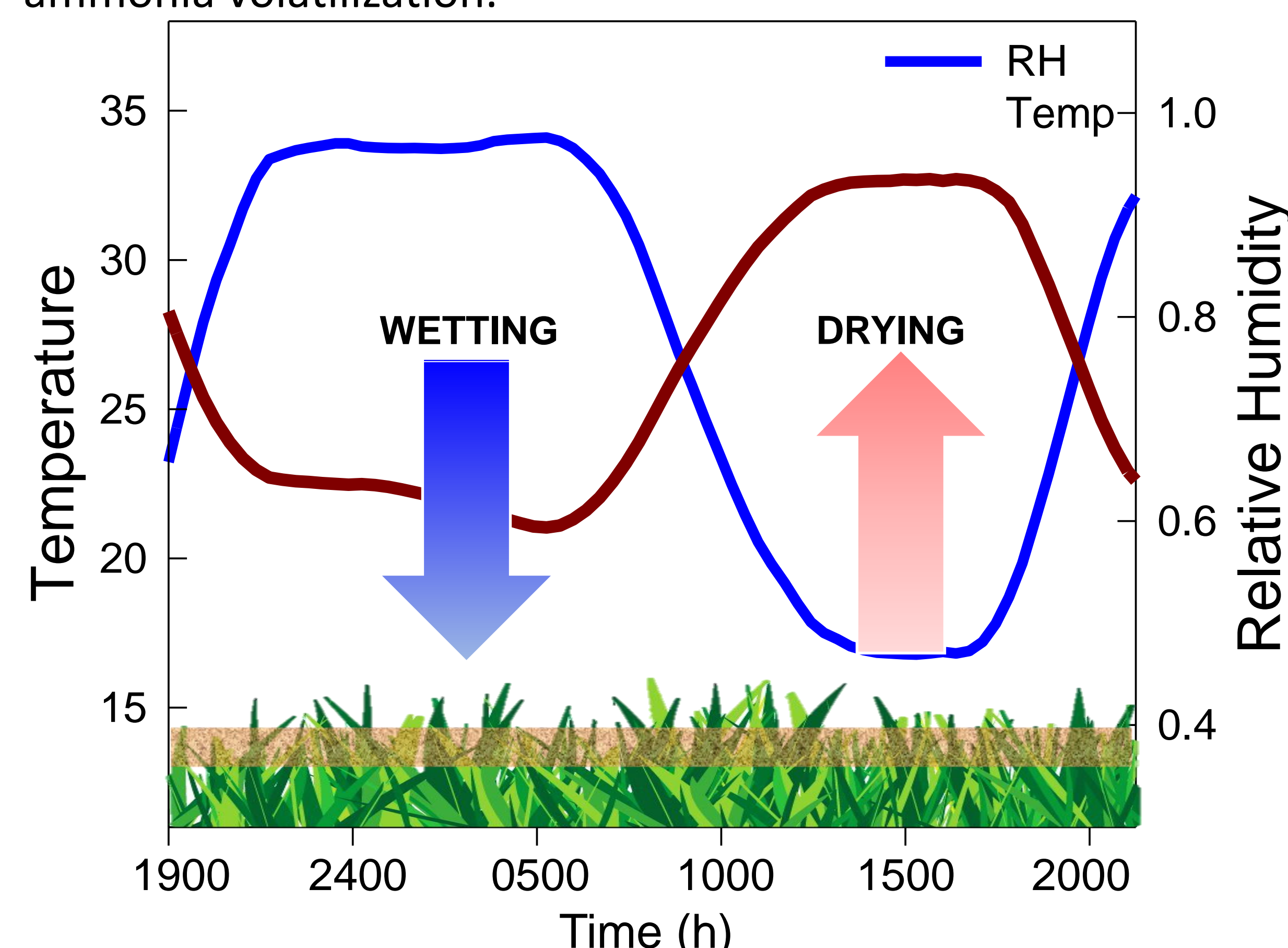


Fig. 1. Hypothesized litter wetting and drying on the pasture surface as a function of RH.

OBJECTIVES

1. Determine the effect of RH on broiler litter WC.
2. Model diurnal changes in broiler litter WC as a function of RH and temperature.

METHODS

Lab Study

1. Broiler litter was placed in WP4-T sampling cups (0.25 or 1.35 g H₂O g⁻¹)
2. Air humidified to 94% or 32%.
3. Samples removed from 0-30 h and WP measured (WP4-T Potentiometer; Decagon Devices)
4. Data were used to determine k coefficient

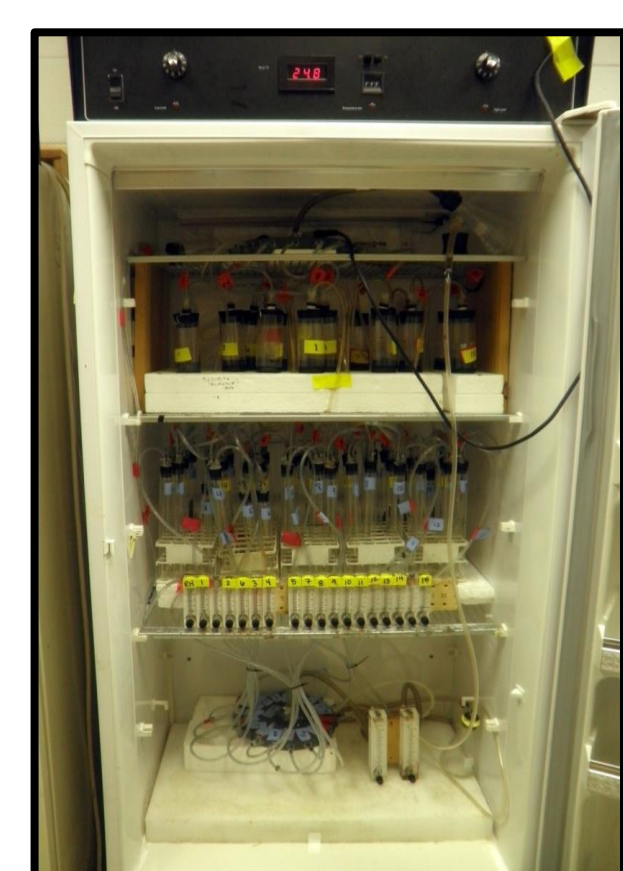


Fig. 2. Dynamic Flow Through System

Field Study

1. Litter was placed in WP4-T sampling cups.
2. Samples placed in field with onsite RH and temperature data-loggers (Decagon Devices).
3. Samples removed periodically (3 reps) from 0-60 h and WP measured.



Fig. 3. Field Experiment

MODELING

$$\frac{dWC}{dt} = -k * \frac{d(Air WP - Litter WP)}{dz}$$

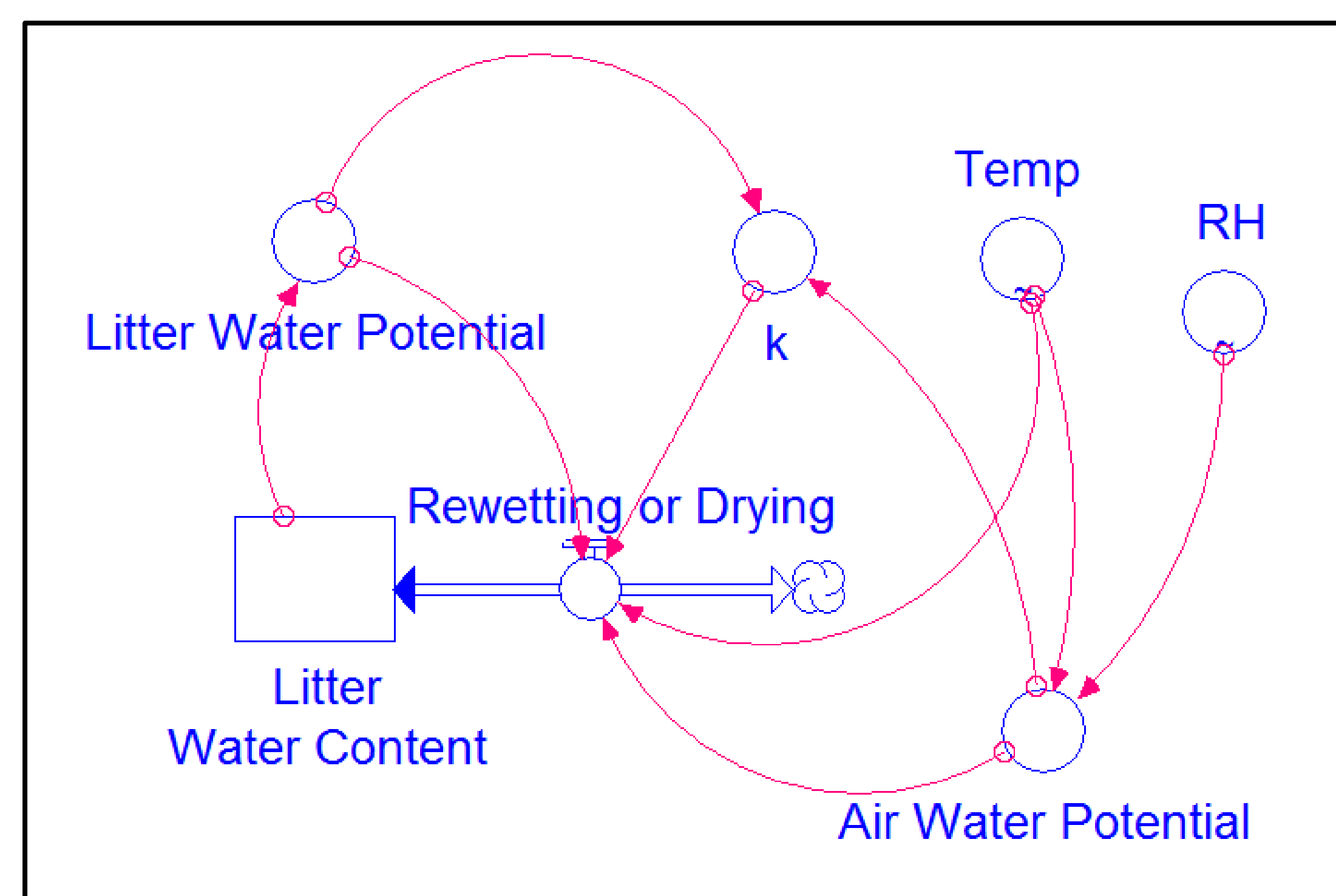


Fig. 4. Model developed using Stella Modeling Software v. 9.0.3 (Isee Systems Inc., Lebanon, NH)

- Air WP and Litter WP in MPa
- k (g H₂O mm (g h MPa)⁻¹)
- dz is depth (mm).

RESULTS: LAB

- Reached equilibrium with atmosphere after 30 h.
- High RH rewetted to -6.4 MPa (0.76 g H₂O g⁻¹).
- Low RH dried rapidly to -154.6 MPa (0.06 g H₂O g⁻¹).
- k = -1.50 * LitterMPa^{-2.27} (for rewetting litter).
- k = -0.0009 + -1.10 x 10⁻⁵ x LitterMPa + 3.52 x 10⁻⁸ LitterMPa² (for drying litter)

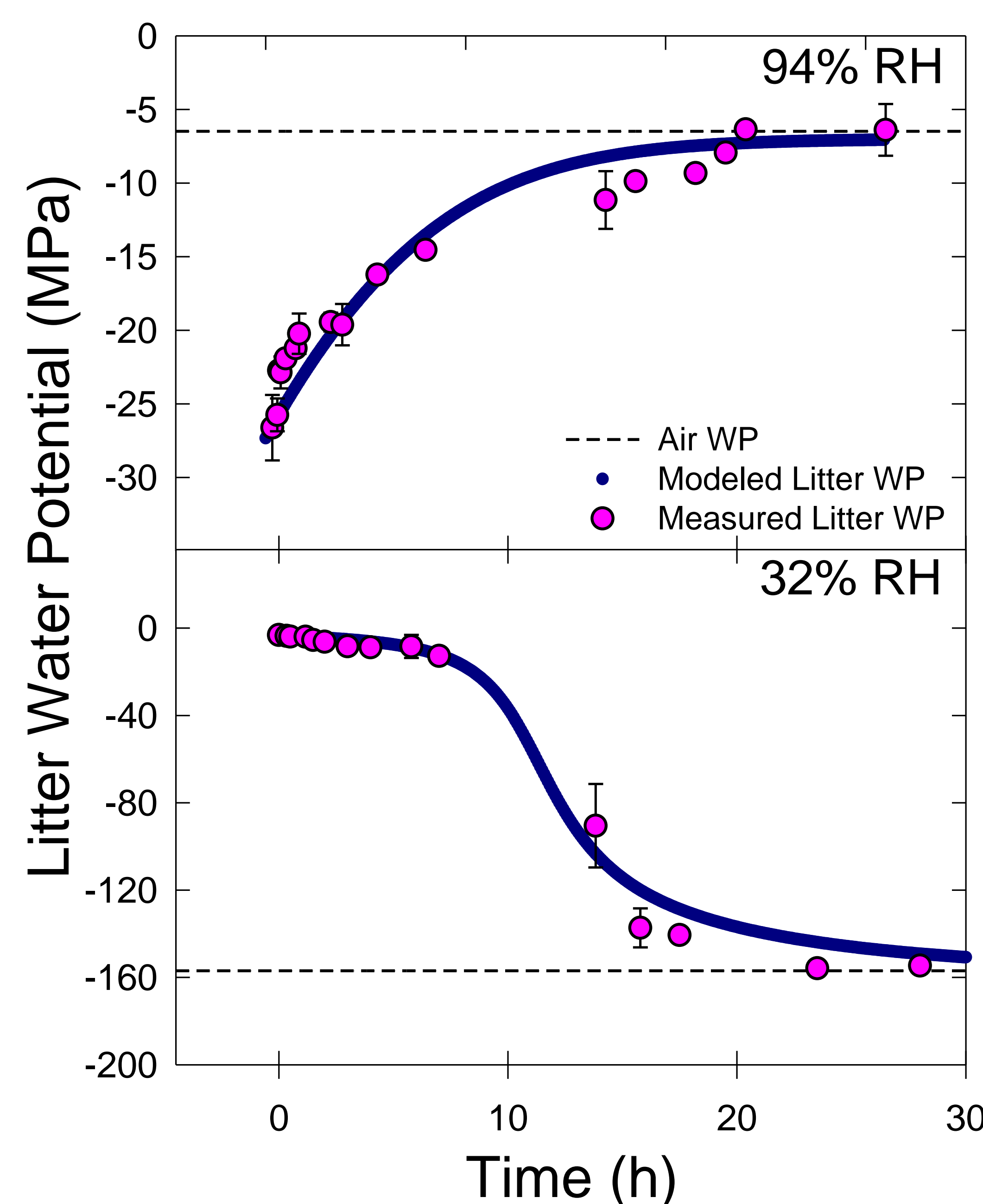


Fig. 5. Measured litter water potential and modeled litter water potential after k constant determination.

RESULTS: FIELD

- Temp fluctuated from 15 to 32°C and RH from 0.39 to 0.95
- Minimum litter WC occurred from 1300 to 1700 h at 0.03 g H₂O g⁻¹ (-270 MPa).
- Maximum measured litter WC occurred early morning near 700 h reaching 0.4 g H₂O g⁻¹ (-14 MPa).
- Adjusting modeling by multiplying the k coefficient by air temperature (°C) increased model accuracy to R²=0.82 where:

$$\text{Measured WC} = 0.82 * \text{Modeled WC} + 0.018$$

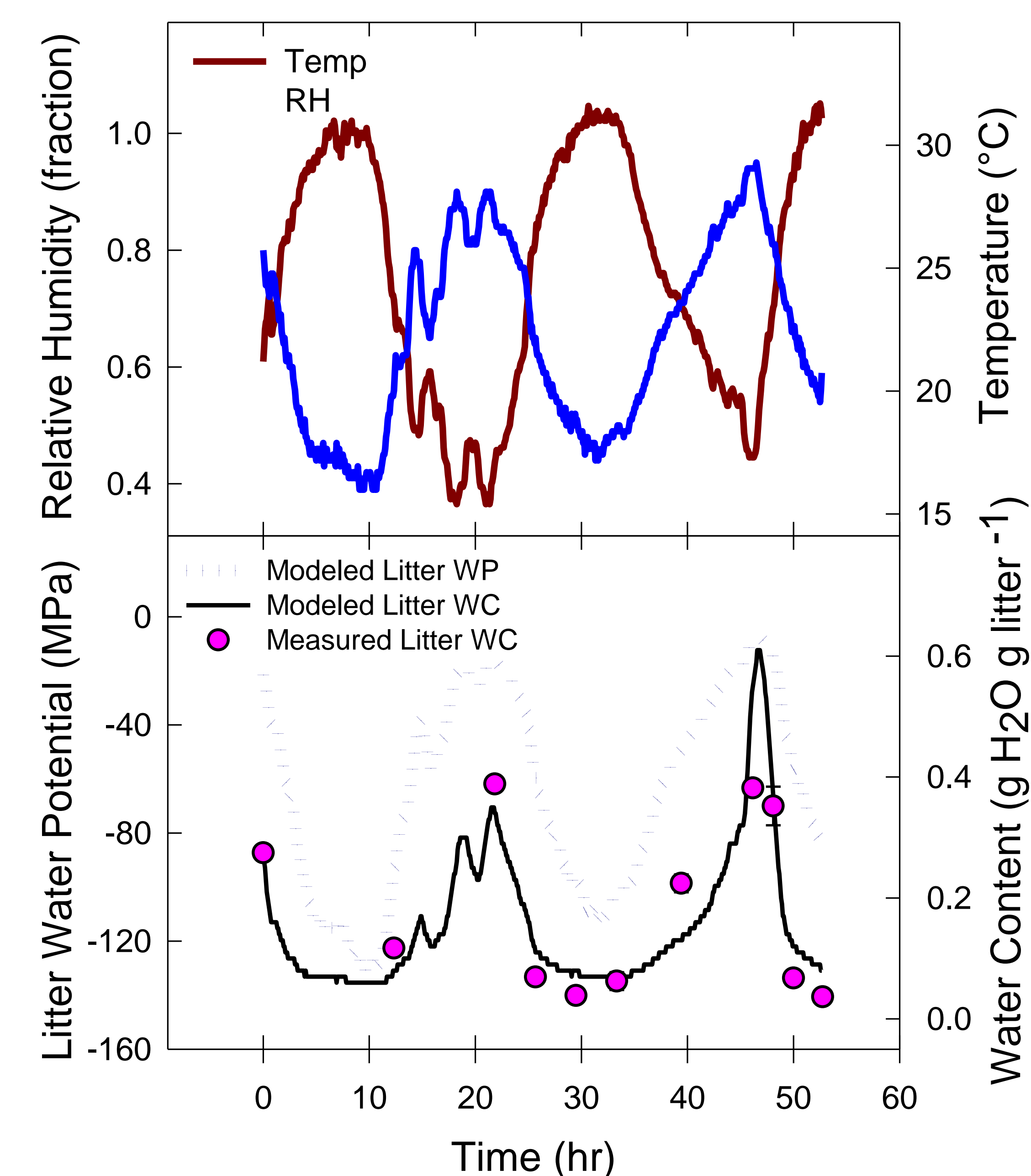


Fig. 6. Temperature, relative humidity, and modeled/measured litter water content for the 60-h field study.

CONCLUSIONS

1. Broiler litter can absorb or lose significant amounts of water to the atmosphere depending on the gradient in water potential.
2. Litter WC will fluctuate on a diurnal basis as function of RH and temperature.
3. WC was accurately modeled, increasing accuracy in modeling nitrogen mineralization and ammonia volatilization from surface-applied litter.

ACKNOWLEDGEMENTS

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