Measurement of salt concentration on the soil surface by the Water Absorption Paper method

○Yuan Wang[1], Hiroaki Terasaki[2], Takuto Kido[3] and Teruyuki Fukuhara[4]

[1]Student member of JSCE, Master course student, University of Fukui

[2]Student member of JSCE, PhD student, University of Fukui

[3]Graduate student, University of Fukui

[4]Member of JSCE, Dr. of Eng., professor, University of Fukui

1. Introduction

We have focused on the salt movement in Chao soil, which is one of the typical salt affected soils in China. Evaporation progresses the salt crystallization on the soil surface, but the growth of the salt crystallization also affects the evaporation rate from the soil surface. We developed the method to directly measure the mass of crystallized salt (direct method), and it was found that the direct method is effective to understand the salt movement near the soil surface[1)]. Moreover, the falling-rate stage of evaporation was observed after the constant-rate stage, although the soil surface was kept wet and the crystallized salt was not observed clearly. The relationship between the appearance of the crystallized salt and the falling-rate stage may be a key to figure out the simultaneous salt and water movement near the soil surface. There has been, however, no study to measure the salt concentration on the soil surface (surface salt concentration) yet.

This paper proposes a new technique “Water Absorption Paper method” to measure the surface salt concentration and discusses the relationship between the commencement of the falling-rate stage and the surface salt concentration.

2. Experimental apparatus and procedure

2.1 Indoor experiment

Fig. 1 shows the schematic view of the experimental apparatus in a temperature and humidity controlled room that consists of a soil column (diameter, = 0.075m and height, = 0.17m), a saline water supply tank and an electric balance. Chao soil was packed in the soil column on condition of the dry soil density of 1600kg/m^3. Saline water with the salt concentration of 10kg/m^3 was supplied into four soil columns initially. One soil column was filled with pure water and Chao soil. To measure the salt concentration near the soil surface in detail, the top 15mm thickness of the soil column was composed of five rings made of vinyl chloride with 3mm in height. The volumetric water content was obtained by the oven-dry method. The evaporation flux was calculated from the time decrement of the weight measured by the electric balance with a minimum reading of 0.1g. The salt concentration was measured with a salt densimeter.

2.2 Water Absorption Paper method

The measurement of the surface salt concentration, C_{surf}, was conducted by the following procedure (see **Fig. 2**): (1)

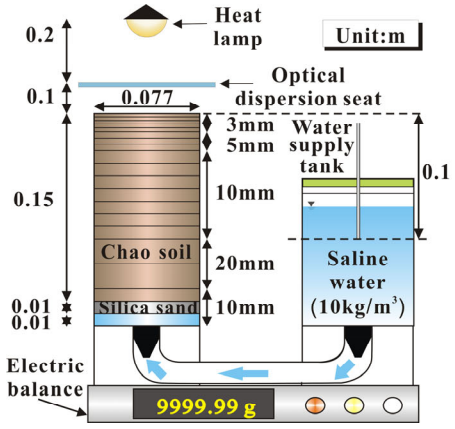

Fig. 1 Schematic view of the experimental apparatus

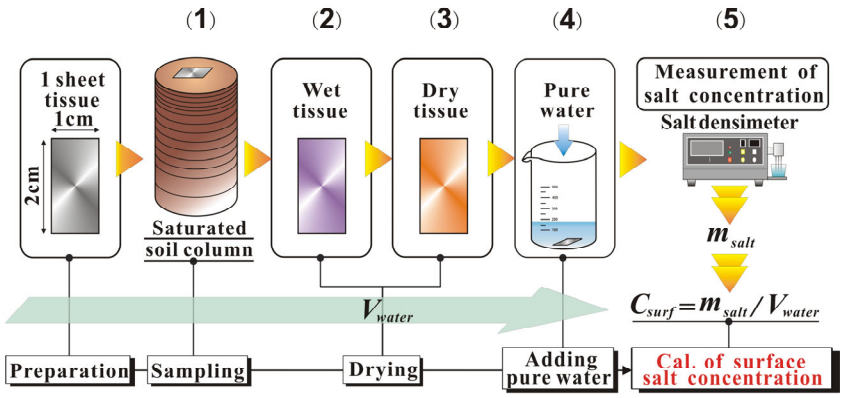

Fig. 2 The Water Absorption Paper method

Keywords: Water Absorption Paper method, soil surface salt concentration, falling-rate period of evaporation, Chao soil

Contact address: Environmental heat and hydraulics Laboratory, University of Fukui, 3-9-1 Bunkyo, Fukui 910-8507, Japan

Tel: 0776-27-8595, Fax: 0776-27-8746, E-mail: wangyuan917@163.com

putting a water absorption paper with a size of 1×2cm on the soil surface to extract the saline water on the soil surface; (2) measuring the paper mass; (3) drying the paper, and calculating the volume of the saline water, V_{water}; (4) stirring 5g of pure water and the paper in a beaker; (5) measuring the salt mass, m_{salt} and then calculating C_{surf}.

C_{surf} was measured every 3 or 6 hours until 48 hours of elapsed time (t = 48 hours).

3. Results and discussions

3.1 Cumulative evaporation

Fig. 3 shows the time variation of cumulative evaporation per unit soil surface area $\sum Q_v$ (kg/m^2). $\sum Q_v$ for fresh water, $\sum Q_{vf}$, increased linearly with time, whereas the time rate of $\sum Q_v$ for saline water, $d\sum Q_{vs}/dt$, started decreasing at $t \fallingdotseq 40$ hours, even though the soil surface was fully wet. This time means the commencement of the falling-rate period. After t = 168 hours, the ratio of $\sum Q_{vs}$ to $\sum Q_{vf}$ was 0.53.

3.2 Surface salt concentration

Fig. 4 shows the time variation of C_{surf}. C_{surf} nonlinearly increased with time and reached to the saturated concentration, C_{sat} (= 362kg/m^3, 44°C) at $t \fallingdotseq 38$ hours, which almost corresponds to the commencement time of the falling-rate period. Therefore, the reduction of evaporation might be affected by the crystallization of salt on the soil surface. The value of C_{surf} at t = 42 hours was a little higher than C_{sat}. This may be caused by the crystallized salt sticked in the paper.

3.3 Vertical profile of salt concentration

Fig. 5 shows the time variation of the vertical profile of salt concentration, C. C of the top layer with a thickness of 3mm, C_{top}, did not reach C_{sat} at t = 72, 120 and 168 hours, respectively, although the salt crystallization had already appeared before t = 72 hours. It is shown that the direct method enables to more preciously evaluate the salt concentration gradient, dC/dz, near the soil surface.

4. Conclusions

It was found that the Water Absorption Paper method is effective to measure the salt concentration on the soil surface. Further investigation will be required to understand the relationship between the occurrence of the falling-rate period of evaporation and the microscopic structure of the saturated saline water on the soil surface.

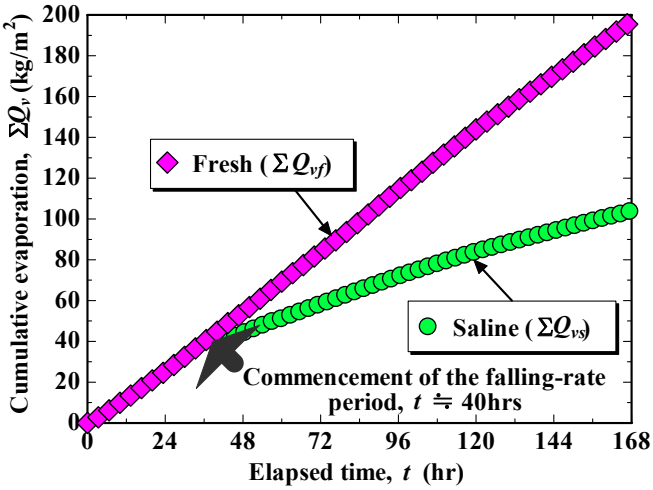

Fig. 3 Time variation of cumulative evaporation

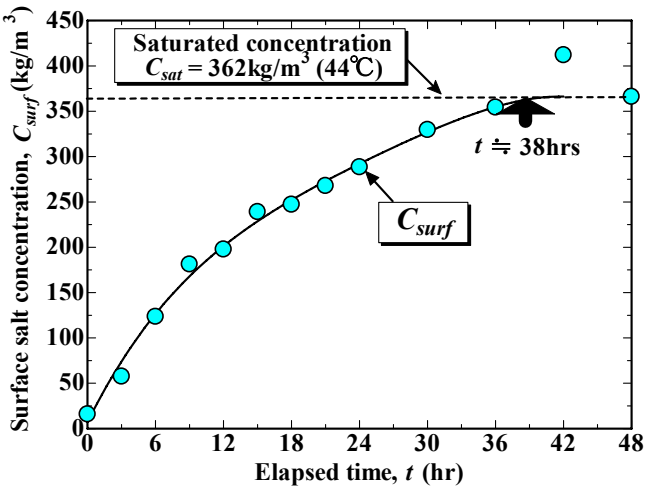

Fig. 4 Time variation of soil surface salt concentration

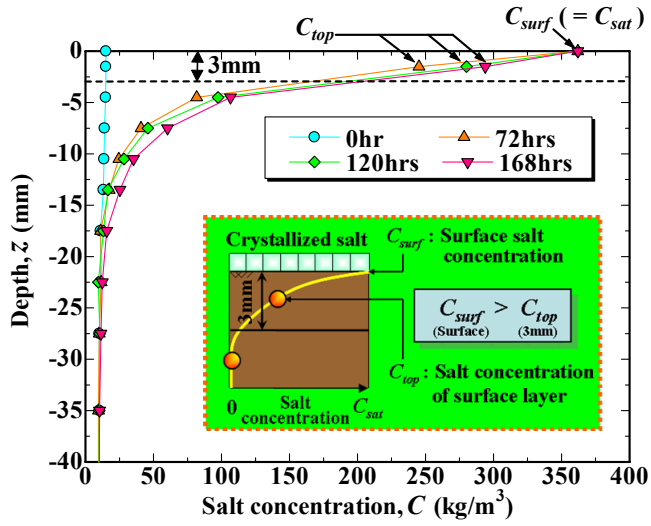

Fig. 5 Time variation of vertical profile of salt concentration

Reference

1) Hiroaki Terasaki, Teruyuki Fukuhara, Hiroki Takeshima: Characteristics of crystallized salt on saturated Chao soil surface by a direct crystallized salt measurement method, Annual Journal of Hydraulic Engineering, JSCE, Vol. 53, pp. 511-516, 2009.