Proc. Indian natn. Sci. Acad., 55, A, No. 3, 1989, pp. 557-561.

THERMAL DIFFUSION OF WATER IN SALINE SOILS (HAPLAQUEPT)

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(*Received 25 March 1988, Accepted 28 March 1988*)

Thermal diffusion of water in two saline soils has been studied. The significance of heat of transport of water, calculated by fitting the experimental data to formulations based on irreversible thermodynamics, across the saline soils and the treated samples has been highlighted. The results agree, on a qualitative level, with the predicted trends.

Key Words : Heat of Transport of Water; Saline Soils (Haplaquept); Treated Saline Soils

INTRODUCTION

THERE have been reports of studies of thermal diffusion of water and aqueous solutions in soil and clap systems.[1-10] In the present paper, thermally induced migrations of water in two saline soil samples, collected from the Sundarban region, has been studied. These experiments were also extended to treated saline soil samples in order to examine "salt effect". The heat of transport of soil water has been calculated by using the experimental data to formulations based on nonequilibrium thermodynamics[5,9] and attempts have been made to derive qualitative information regarding soilwater interactions therefrom.

MATERIALS AND METHOD

Two saline soil (Haplaquept) samples, collected respectively, from Sajnekhali and Bakkhali of Sundarban region of West Bengal, having different physico-chemical properties, were used for the present study. The soil samples were air-dried, crushed and passed through 0.2 mm seive. Then some of the soil samples of each region were leached with distilled water in order to reduce the free soluble salts. The saline soil sample from the Sajnekhali region was leached to EC_e values of 2.77 and 0.97m mhos/cm which are denoted as SL_1 and SL_2 respectively. The saline soil sample from the Bakkhali region was leached to EC_e 3.88 and 1.44m mhos/cm and symbolised BL_1 and BL_2. Organic manure such as FYM was added @ 20t/ha and 60t/ha to the Sajnekhali saline soil to obtain the samples S_2 and S_3 and to the Bakkhali soil to obtain the samples B_2 and B_3 respectively.

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Further some original samples of Sajnekhali and Bakkhali region were also treated with 10 per cent H_2O_2 and thus freed from organic matter. These are symbolised as S_1 and B_1, respectively. To some portion of saline soil samples of Sajnekhali and Bakkhali region, gypsum @ 25 per cent of measured gypsum requirement was added to reclaim these soils and samples obtained are Sg and Bg, respectively.

The important physicochemical properties of the given soil samples as well as the treated samples were determined by following the standard procedures[11,12] and are presented in Tables I to III.

TABLE I

Physical properties of the soils

Sample	Mechanical separates/ per cent			Soil texture	Water holding capacity/ per cent	Bulk density/ g cm^{-3}	True density/ g cm^{-3}	Pore space/ per cent
	Sand	Silt	Clay					
Sajnekhali	34.4	40.6	25.0	Silty clay loam	43.27	1.16	2.41	51.87
Bakkhali	18.0	44.0	38.0	Clay loam	47.77	1.12	2.46	54.87

TABLE II

Chemical characteristics of the soils

Sample	*p*H (1:2.5)	EC_e/ m mhos cm^{-1}	T.S.S./ per cent	Organic Carbon/ per cent	C.E.C./ mg2 $(100g)^{-1}$	Exchangeable Cation/ me$(100g)^{-1}$				Base satura-tion/ per cent	Gypsum require-ment/ $t.ha^{-1}$
						Ca^{+2}	Mg^{2+}	Na^{+}	K^{+}		
Sajnekhali	8.0	7.07	1.85	0.59	12.77	5.87	2.88	1.01	0.85	83.08	4.25
Bakkhali	8.45	14.40	4.15	0.89	14.71	6.20	3.80	2.10	0.94	88.65	7.66

The non-isothermal diffusion cell (Fig. 1) used here was based on a design by Sanyal and Bandyopadhyay,[8] in which the central soil chamber was sandwiched between terminal chambers and a horizontal temperature gradient was imposed across each soil/water boundary. The diffusion experiments were performed with the saline soil and reclaimed soil samples; each sample was moistened to the corresponding maximum water holding capacity. The heat of transport of water was obtained by having recourse to a relation, namely,

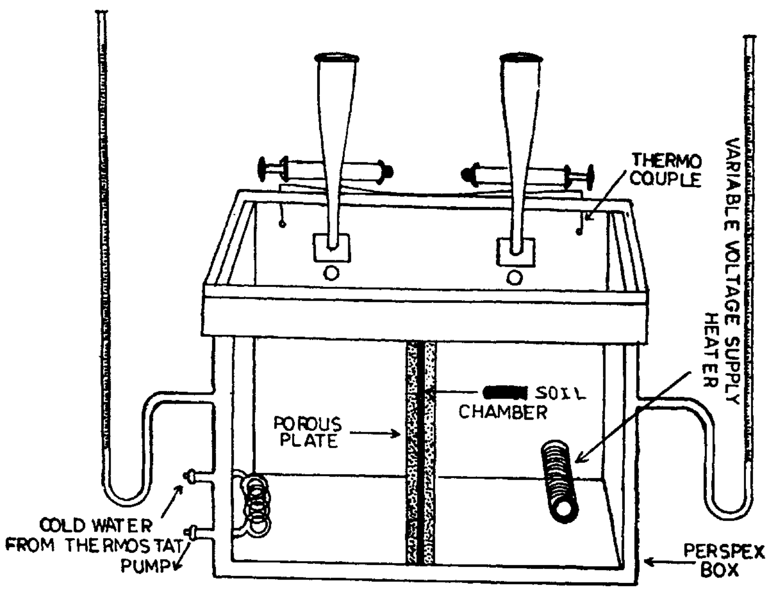
$$\hat{Q}_w = - \bar{V}_w \, T(\Delta P/\Delta T)_{st},$$

where, V_w is the molar volume of water, T is the mean (absolute) temperature while $(\Delta P/\Delta T)_{st}$ refers to the steady state value across the soil chamber.[13]

TABLE III

Physicochemical characteristic of the treated soils

Sample	*p*H (1:2.5)	EC_e m mhos cm^{-1}	T.S.S/ per cent	Water holding capacity/ per cent	Bulk density/ g cm^{-3}	True density/g cm^{-3}	Pore space/ per cent
SL_1	7.95	2.77	0.84	50.42	1.14	2.50	53.20
SL_2	7.90	0.97	0.34	57.98	1.13	2.52	55.16
BL_1	0.25	3.88	1.20	51.22	1.09	2.48	56.85
BL_2	8.15	1.44	0.53	61.02	1.07	2.51	37.37
S_1	8.05	8.00	1.98	41.10	1.21	2.44	50.41
S_2	7.60	3.50	1.06	50.15	1.13	2.40	52.92
S_3	7.50	2.70	0.88	53.99	1.11	2.44	54.51
B_1	8.40	11.30	3.06	44.86	1.15	2.50	53.76
B_2	8.15	7.00	2.60	57.43	1.09	2.44	55.53
B_3	7.80	5.80	2.01	61.57	1.06	2.46	56.91
S_g	7.35	3.15	0.98	51.78	1.15	2.52	54.37
B_g	8.10	6.46	2.15	55.07	1.11	2.55	56.47



SCHEMATIC DIAGRAM OF THE APPARATUS USED

FIG 1

RESULTS AND DISCUSSION

The heat of transport values of water ($\hat{Q}_w$) in the given saline soil and the treated samples are entered in the tables 4 to 6. In each case the values are mean of

TABLE IV

Heat of transport of water in saline soils at various degrees at leaching

Sample	pH (1 : 2 : 5)	EC_e m mhos cm^{-1}	TSS per cent	Water holding capacity/ per cent	Mean Temperature (T)Å	V_w ml mol^{-1}	ΔT/Å	$-\left(\frac{\Delta P}{\Delta T}\right)_{st} \times 10^3$ atm deg^{-1}	$\hat{Q}_w$ $J\ mol^{-1}$
Sajnek-hali Soil	8.0	7.07	1.85	43.27	310.01	18.08	4.0	2.07	1.18 (± 0.014)
SL_1	7.95	2.77	0.84	50.42	310.5	18.07	5.0	2.20	1.25 (± .010)
SL_2	7.90	0.97	0.34	57.98	310.5	18.09	4.0	2.23	1.27 (± 0.035)
Bakkhali Soil	8.35	14.4	4.15	47.77	310.0	18.08	4.0	2.02	1.15 (± 0.014)
BL_1	8.25	3.88	1.20	51.22	310.3	18.08	4.0	2.24	1.27 (± 0.023)
BL_2	8.15	1.44	0.53	61.02	310.3	18.09	4.7	2.26	1.29 (± 0.024)

TABLE V

Heat of transport of water in saline soils at various dozes of FYM

Sample	FYM addition/ t. ha^{-1}	Mean temperature (T)/Å	ΔT/Å	V_w/ml mol^{-1}	$-\left(\frac{\Delta P}{\Delta T}\right)_{st} \times 10^3$ atm deg^{-1}	$\hat{Q}_w$/$J\ mol^{-1}$
Sajnekhali Soil	—	310.0	4.0	18.08	2.07	1.18 (± 0.014)
S_1	—	310.0	4.0	18.08	2.17	1.23 (± 0.012)
S_2	20.0	310.0	4.0	18.08	20.05	1.16 (± 0.013)
S_3	60.0	310.0	4.0	18.08	1.98	1.11 (± 0.021)
Bakkhali Soil	—	310.0	4.0	18.09	2.02	1.15 (± 0.014)
B_1	—	310.0	4.0	18.09	2.20	1.25 (± 0.016)
B_2	20.0	310.0	4.0	18.07	1.99	1.13 (± 0.021)
B_3	60.0	310.0	4.0	18.08	1.92	1.09 (± 0.021)

TABLE VI

Heat of transport of water in saline soils after treatment with gypsum

Sample	pH (1 : 2.5)	EC_e m mhos cm^{-1}	T.S.S/ per cent	Mean temperature (T)/Å	ΔT/Å	V_w ml mol^{-1}	$-\left(\frac{\Delta P}{\Delta T}\right)_{st} \times 10^3$ atm deg^{-1}	$\hat{Q}_w$ Jmol^{-1}
Sajnekhali soil	8.00	7.07	1.85	310.0	4.0	18.08	2.07	1.18 (± 0.014)
S_g	7.35	3.15	0.98	310.0	4.0	18.08	2.24	1.27 (± 0.021)
Bakkhali soil	8.35	14.40	4.15	310.0	4.0	18.08	2.02	1.15 (± 0.014)
B_g	6.46	6.46	2.15	310.0	4.0	18.08	2.31	1.31 (± 0021)

three determinations conducted under identical experimental set up. The corresponding standard deviations are shown in the parenthesis below the appropriate $\hat{Q}_w$ values (*vide* Tables IV to VI.)

The heat of transport of water ($\hat{Q}_w$) is seen to positive which corresponds to an absorption of heat behind the diffusing soil water and a liberation ahead in course of diffusional transport through the soil.[5,14] A plausible explanation may be sought in the light of local degree of orderliness of water before it enters the soil chamber and that in contact with soil particles.

The heat of transport of water ($\hat{Q}_w$) increases with decreasing specific conductance value (Table IV), i.e., with the removal of free soluble salts (predominantly chlorides). This may possibly be attributed to the disruptive effect of chlorides on structure of water.[14] The heat of transport values of water decreased with the addition of FYM (*vide* Table V). The latter is expected to exert a strong ordering influence on water as compared to the original soil.[8,15] This should cause a corresponding lowering in $\hat{Q}_w$ with the gradual addition of organic manure as FYM. The heat of transport value are also seen to increase after reclaiming with gypsum (*vide* Table VI). This is possibly due to replacement of sodium by calcium ion in the exchange complex which leads to greater loss of "local" entropy of water in the soil chamber, causing a higher value of heat of transport of water ($\hat{Q}_w$).

ACKNOWLEDGEMENT

The authors wish to thank Professor S K Mukherjee, D.Sc., FNA for his suggestions to improve the contents of this paper.

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