INTERNATIONAL ATOMIC ENERGY AGENCY
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COLLEGE ON SOIL PHYSICS

19 September - 7 October 1983

MOVEMENT OF SOLUTES: CONVECTION, DIFFUSION, DISPERSION, MISCIBLE DISPLACEMENT - TRANSPARENCIES

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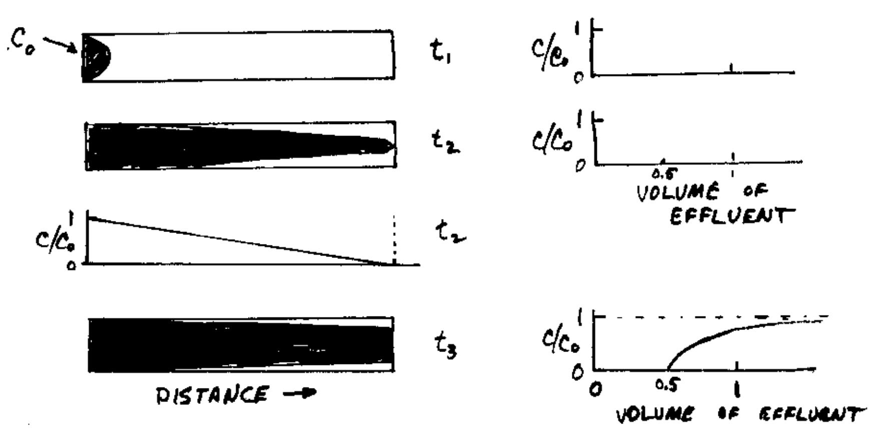
SOLUTE MOVEMENT BY CONVECTION

1.



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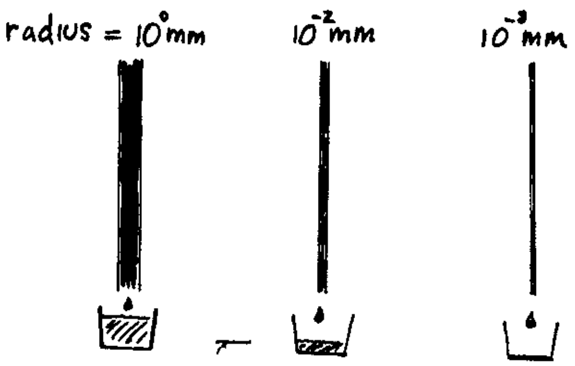


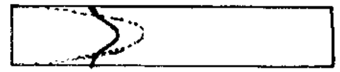
$$Q = \frac{\pi r^4 \Delta P}{8 \eta L}$$

3.

SOLUTE MOVEMENT BY DIFFUSION

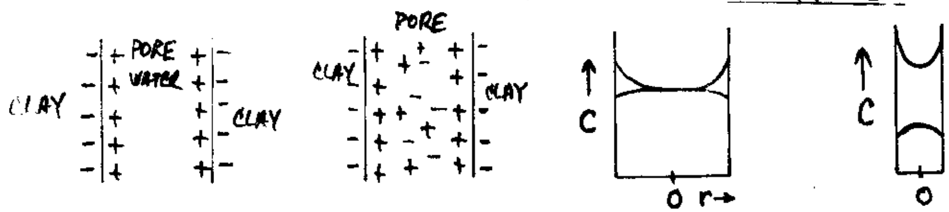
1. $$J_{SOLUTE} = -D\theta \frac{dC}{dx}$$

2.

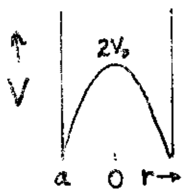


3.

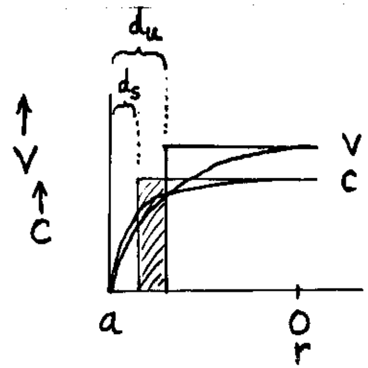
ELECTRIC FIELD IN VICINITY OF SOIL PARTICLES



WATER VELOCITY IN VICINITY OF SOIL PARTICLES



$$V = 2V_0\left(1 - \frac{r^2}{a^2}\right)$$

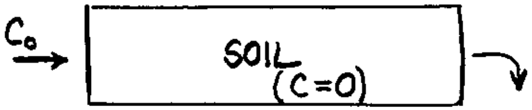


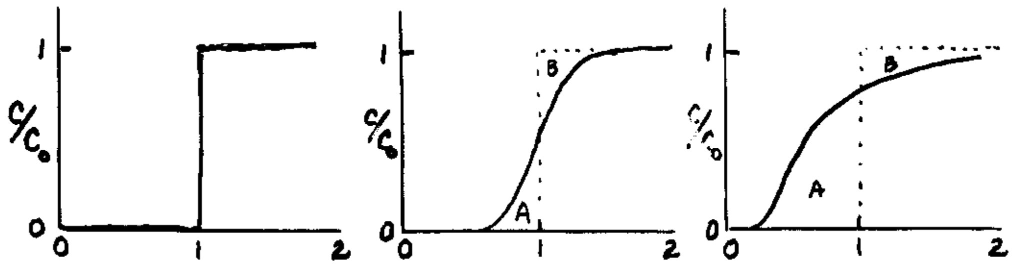
1

SOLUTE MOVEMENT

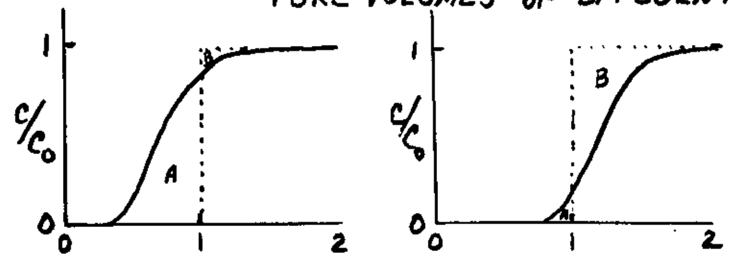
$$J_s = -D\theta \frac{dc}{dz} + J_w c$$

$$\frac{\partial c}{\partial t} = \frac{\partial}{\partial z}\left[D \frac{\partial c}{\partial z}\right] - \frac{\partial v c}{\partial z} \qquad v = \frac{J_w}{\theta}$$



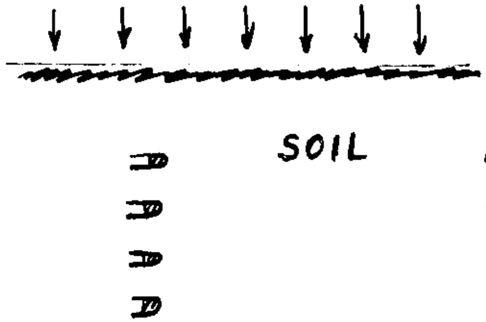


PORE VOLUMES OF EFFLUENT



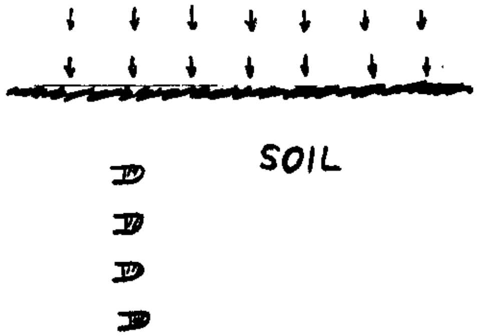
PORE VOLUMES

CONTINUOUS PONDING

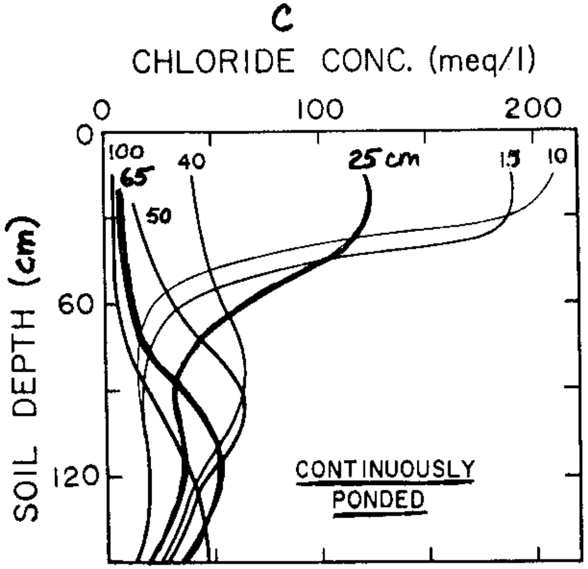


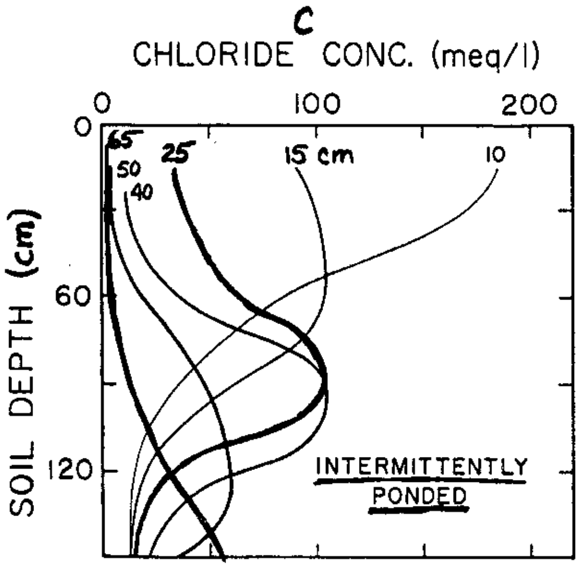
NEARLY WATER-SAT'D
LARGE J_w

INTERMITTENT PONDING OR SPRINKLING



WATER UNSAT'D
SMALL J_w





LABORATORY EXAMPLE - LEACHING UREA

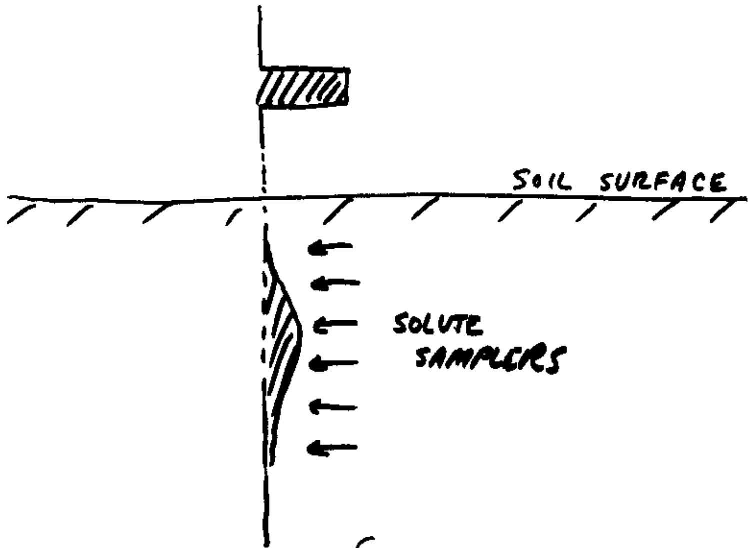
FIELD EXAMPLE - LEACHING EFFICIENCY

FIELD EXAMPLE - VARIABILITY IN 1 PLOT

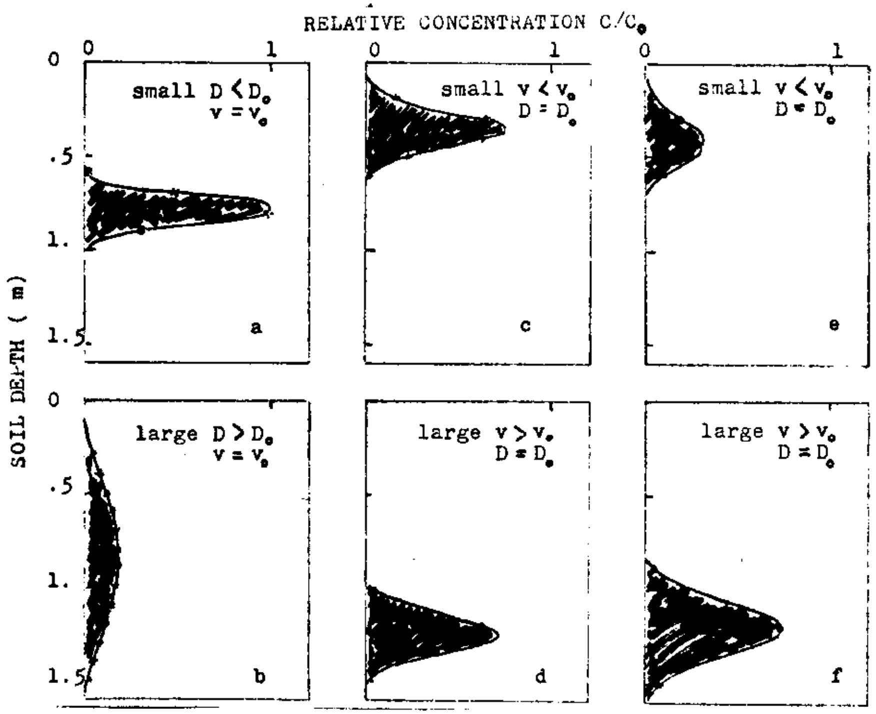
FIELD EXAMPLE - VARIABILITY IN 20 PLOTS

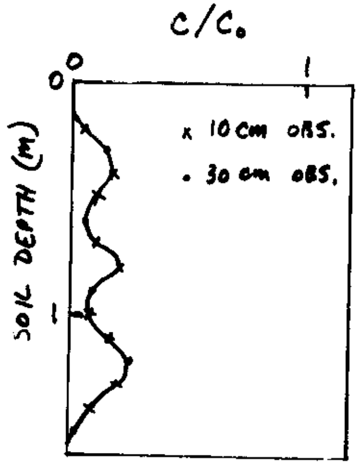
FIELD EXAMPLE - AVERAGE BEHAVIOR

1. AT ONE SITE
2. ACROSS ENTIRE FIELD



WE EXPECT ANYWHERE IN THE (x, y) PLANE OF THE FIELD, A WIDE VARIETY OF SOLUTE DISTRIBUTIONS





HOW IS AN "AVERAGE" SOLUTE DISTRIBUTION APPROPRIATELY OBTAINED?

THERE ARE TWO KINDS OF AVERAGES

1. THAT EXPECTED AT ANY 1 LOCATION.
2. THAT EXPECTED AVERAGED OVER ALL LOCATIONS.

WE SHALL ASSUME:

1. V, D, θ, C ARE RANDOM VARIABLES CHARACTERIZED BY EACH OF THEIR FREQUENCY DISTRIBUTIONS.

2. EACH FREQUENCY DISTRIBUTION IS STATISTICALLY STATIONARY OVER ENTIRE FIELD.

$$\bar{c}(z,t) = \int_0^1 c\, f(c|z,t)\, dc$$

WHERE f IS THE RELATIVE FREQUENCY DISTRIBUTION OF C.

WE SHALL COMPUTE $\bar{c}(z,t)$ WITH THE FOLLOWING MONTE CARLO SIMULATION PROCEDURE:

1. DRAW A RANDOM VALUE β FROM THE NORMAL DISTRIBUTION WITH MEAN = 0, VARIANCE = 1.

2. CALCULATE A RANDOM VALUE OF $\ln D$ FROM ITS FREQUENCY DISTRIBUTION VALUE OF MEAN μ AND STANDARD DEVIATION σ USING:

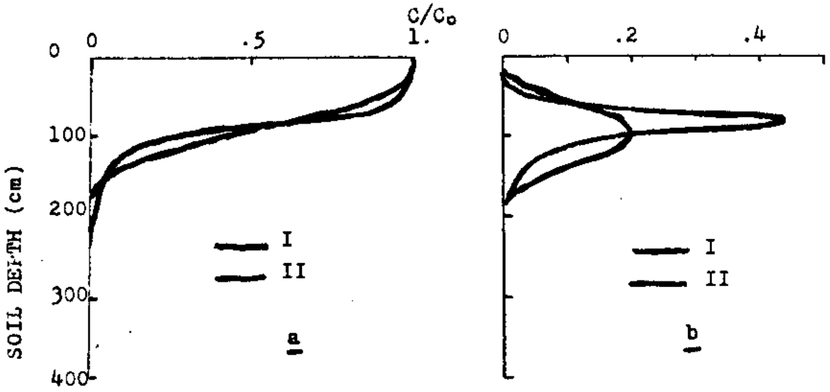
$$y = \beta\sigma + \mu$$

3. CALCULATE A RANDOM VALUE OF C/C_0 FROM SOLUTION OF THE CONVECTIVE-DIFFUSION EQUATION USING ABOVE RANDOM VALUES OF V, D, θ FOR EACH z, t.

4. REPEAT STEPS 1-3 FOR 2000 TIMES AND CALCULATE $\bar{c}(z,t)$.

STEP INPUT OF SALT

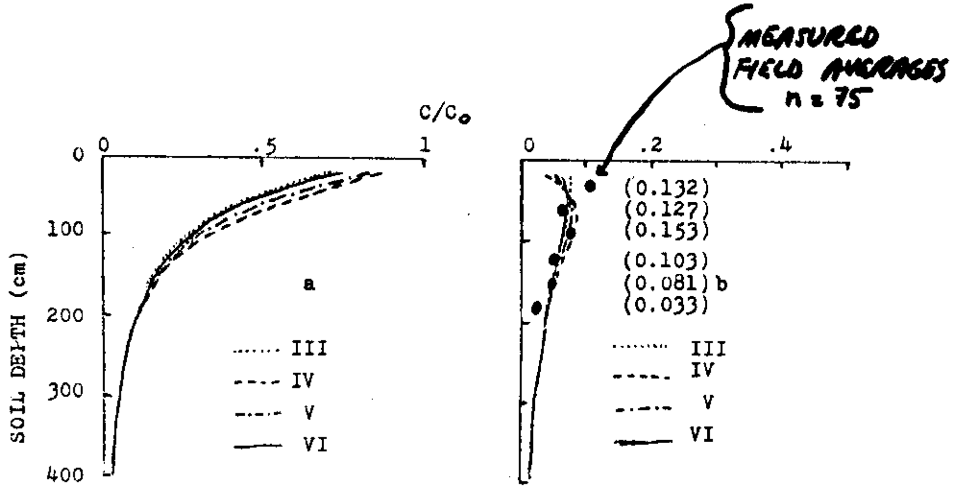
PULSE INPUT OF SALT



I $V = 44.3$, $\theta = 0.428$, $D = 378$

II $V = 44.3$, $\theta = 0.428$, $D =$ VARIABLE

SALT DISTRIBUTIONS AVERAGED ACROSS THE ENTIRE FIELD.



CHOICES OF V, θ, D FOR MONTE CARLO SIMULATIONS

CASE	V (cm/d)	θ (cm³/cm³)	D (cm²/d)
I	44.3	0.428	378
II	44.3	0.428	VARIABLE 3/
III	VARIABLE 1/	VARIABLE 2/	0
IV	VARIABLE	VARIABLE	378
V	VARIABLE	VARIABLE	VARIABLE
VI	VARIABLE	VARIABLE	$0.6 + 2.93V^{1.11}$

1/ $\ln V \sim N(3.01, 1.25^2)$ 2/ $\theta \sim N(0.428, \text{[illegible]}^2)$ 3/ $\ln D \sim N(4.42, 1.74^2)$