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Hydrodynamic Dispersion Coefficient of Urea in Silty Loam Soil

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ABSTRACT

The modern theme of agriculture is not only to increase production but also to minimize undesirable environmental effects. Leaching of surface-applied fertilizer is the major source of groundwater pollution. Nitrogenous fertilizers are the most popular among the Indian farmers, which on leaching reach the groundwater in different forms (NH_4-N, NO_3-N, etc). NO_3-N leaches faster than other types, remains in-reactive in groundwater, moves with the velocity of groundwater and contaminates it. Contamination arises when NO_3-N accumulates in groundwater and consumed in high amount by humans and animals, may result in adverse health effects. For the study of contaminant transport phenomenon in porous medium, a general convection dispersion equation is used, in which dispersion coefficient is one of the primary parameters necessary to be determined for a particular soil. Keeping it in view a study was conducted to assess different available techniques to determine the dispersion coefficient with the help of soil columns having silty loam soil as soil medium. The value of the dispersion coefficient obtained for silty loam soil, by this method was equal to 0.00576 m^2.

KEYWORDS

Dispersion coefficient urea , ground water, contamination.

INTRODUCTION

Intensive agriculture, with high use of synthetic fertilizers and chemical pesticides, was introduced in India in the 1960s as part of the Green Revolution. As a result, synthetic fertilizers' consumption increased from a mere 0.07 million tonnes (Mt) in 1950-51 to a staggering 26.59 Mt in the year 2017-18 (Anonymous, 2018), a drastic have than 300 times increase. The synthetic fertilizer usage in the country shows significant variation from region to region. However, in most agriculture intensive districts (78 districts out of 528 major districts in India), synthetic N-P-K (nitrogen, phosphorus and potassium) fertilizer consumption is more than 200 kg/ha, a rate that is twice the country average. The irrigated area, accounting for 40 percent of the total agricultural area, receives 60 percent of the total fertilizer applied. An unthoughtful use of chemicals may render agricultural land, water and air inefficient for supporting life. Unfortunately, most of the public environmental protection programs are urban-oriented, whereas the pollution and its direct effects in the local sectors are ignored as much as 50 to 70% of the water resources are polluted due to contamination from agricultural activities. Groundwater pollution due to nitrates is increasing in India. The water quality assessment studies carried out in 17 Indian states by National Environmental Engineering Research Institute (NEERI) showed that out of 4,696 water samples, 1,290 samples (27%) have nitrate exceeding the drinking water standard (Bulusu and Pande, 1990). The nitrate concentration of well water has shown rising trends in many countries with in the last 30 years (Guarda *et al.*, 2004).

To assess the contaminant transport phenomenon in saturated and unsaturated soil system the precise values of parameters of the general convection dispersion equation [eqn. 1], is required, which may be used to predict solute concentration in time and space with reasonable accuracy by applying sufficient and appropriate initial and boundary conditions.

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2} = V\frac{\partial C}{\partial x} - kC \quad \ldots(1)$$

Where,

D = Dispesion coefficient, (M^2T^{-1})
V = Average interstitial velocity, (MT^{-1})
k = Rate of transformation of urea, (T^{-1})
C = Concentration of applied solute at any point x, after time, t. (ppm)

For the successful prediction of contaminant transport in groundwater, the excat value of different coefficients of the convection-dispersion equation is necessary. The dispersion coefficient is one of the most important and difficult parameters, which is also required. Therefore, in this paper, an attempt has been made to study the comparative performance of different available techniques to determine the dispersion coefficient.

MATERIALS AND METHODS

The hydrodynamic dispersion of urea in soil was studied with the help of soil water samplers and tensiometers installed in the experimental plot. Three soil-water samples were selected for the recording of data. The experimental plot was developed at the experimental site of the Department of Irrigation and Drainage Engineering, College of Technology, G.B. Pant University of Agriculture and Technology, Pantnagar. The selected location was fallow and unused for a long

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time. This site was chosen to avoid the preferential flow through the soil. The plot was leveled and the galvanized iron sheet was inserted into the ground at the outer and inner boundary of the plot. To resemble the double-ring infiltrometer and check the horizontal movement of solute from the inner portion to the buffer zone of the plot. Four tanks of 500-liter capacity were kept at the corners of the plot for the application of fertigation. After installation of the sheet, topsoil was again leveled and flooded in quick succession for settlement of soil. Soil water samples were recorded at different depth and intervals for calculation of dispersion coefficient.

The size of the experimental plot was 5 m x 5m. The line of tensiometers and soil water samplers were put 1.5 m away from the side boundary. The positions of these fittings are shown in Fig. 1. The depth of both tensiometer and samplers were kept 15, 30, 50, 100, and 150 cm below the ground surface. First and sixth tensiometers were installed 50 cm away from the boundary wall and the distance between two was kept 80 cm.

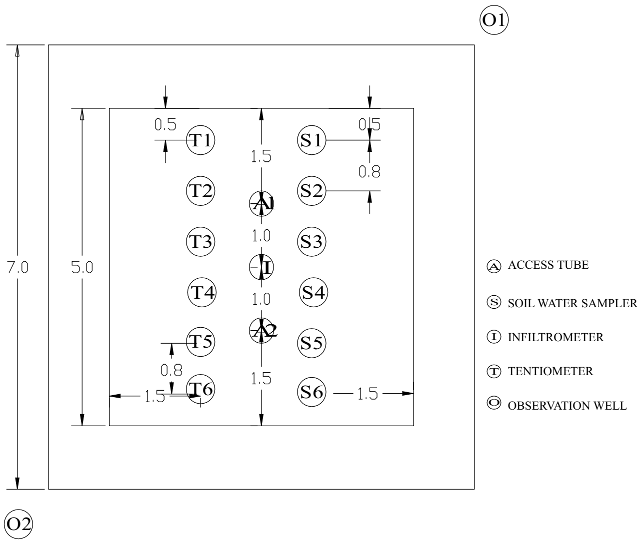

Fig. 1 : Layout of Experimental Plot

For determination of dispersion coefficient, the nitrogen concentration of soil samplers S_1, S_2 and S_3 and corresponding pore volume of water from tensiometer was recorded at different depth and time and henceforth mentioned as points C_1, C_2 and C_3. The dispersion coefficient was obtained by four different methods used by Ram Pal (2002 & 2019)

Kirkham and Powers (1972) proposed the following expression for the determination of the dispersion coefficient (D):

$24/SVxDp=$ …(2)

where S is the slope of the dimensionless curve drawn between relative concentration and pore volume.

Basak and Murty (1979) proposed a method by using "inverfc" for the determination of the dispersion coefficient. It gives the expression for the dispersion coefficient as follows:

$$D \quad \frac{M \;\; x/Vt\text{-}1^2}{tu^2} \qquad \ldots(3)$$

$$M \quad 0.25\ invefc\ 2C/C0^2 \qquad \ldots(4)$$

If L is the length of the soil column and the time required for the concentration (C/C_0) to reach a value of 0.1 at x=L is $t_{0.1}$, then M=0.30443.

Gupta and Singh (1980) proposed an improved method for evaluating the hydrodynamic dispersion coefficient by using significant portion of the dimensionless curve rather than a point value, which may be prone to measurement errors.

They drew a graph inverfc ($2C/C_0$) vs. $\left[\frac{x-Vt}{2\sqrt{t}}\right]$ and found the slope of this straight line. Square of the slope gives the value of dispersion coefficient.

$D=S^2$ …(5)

Where S is the slope of the straight line.

Pandey and Gupta (1984) proposed a method for the determination of dispersion coefficient by evaluating solute transport at one pore volume (P=1), as follows:

$D= Vd\pi(L_f)^2$ and …(6)

$Lf=1/\sqrt{B}$ …(7)

Where L_f is the leachate fraction at one pore volume and B is the Peclet Number.

RESULTS AND DISCUSSION

The dispersion coefficient was determined by using equations 2 to 7, taking the requisite values from the plot of relative concentration versus pore volume (Fig. 2), and plot between inverfc ($2C/C_0$) and (x-Vt)/t2 (Fig. 3) for different soil points. The obtained values of the dispersion coefficient are shown in Table 1.

Table 1: Dispersion coefficient values for different soil columns calculated by different methods

Points	Kirkham and Powers (1972)	Basak and Murty (1979)	Gupta and Singh (1980)	Pandey and Gupta (1984)
C_1	0.19159	0.01973	0.00566	0.0410
C_2	0.22603	0.023053	0.00596	0.0318
C_3	0.24752	0.023049	0.00576	0.0382

Table 1 shows that the dispersion coefficient of urea in silty loam soil was found to be maximum (0.24752 m^2/hr) when determined by technique given by Kirkham and Powers (1972) and minimum (0.00566 m^2 /hr) when assessed by technique given by Gupta and Singh (1980).

As per the theoretical background reported by Bear (1961), the dispersion coefficient should be constant for lower concentration, but it may vary for higher concentration. A close look at Table 1 shows that the variation in the dispersion coefficient is less when determined by Gupta and Singh (1980) method. Therefore, the dispersion coefficient of urea is 0.00576 m^2/hr and Gupta and Singh (1980) are the best suitable method for determination of Dispersion Coefficient of urea in silty loam soil.

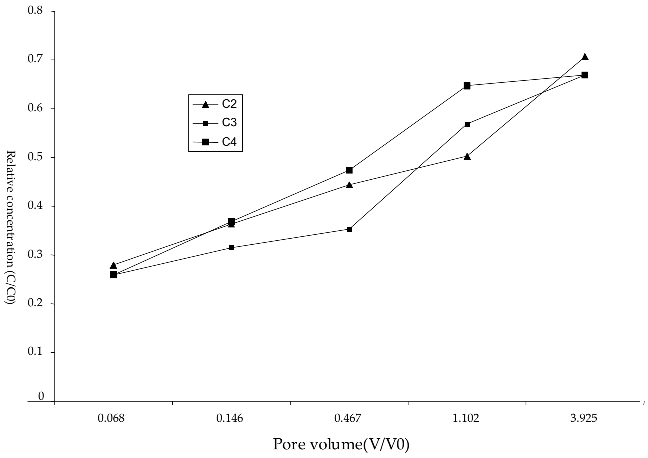

Fig. 2: Dimensionless curves for soil columns C1, C2 and C3

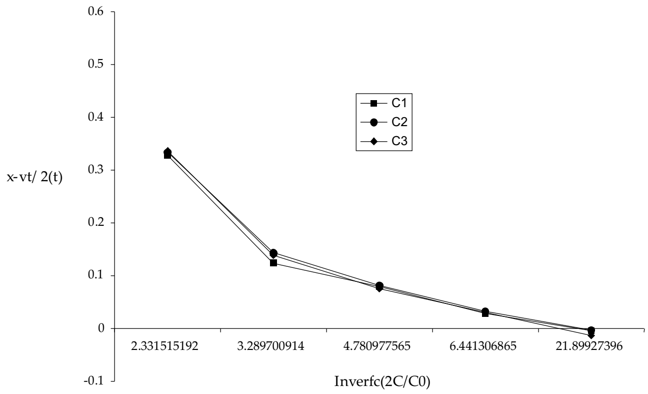

Fig. 3: Variation of x-vt/ 2(t) 1/2 with inverfc (2C/C0) For columns C1, C2 and C3

Soil structure, physical and chemical features of soil and the applied chemical is responsible for the hydrodynamic dispersion coefficient. Hence, it may be different for different locations and solute. When this value of dispersion coefficent is put in solution of Eq. 2, the predicted and observed values of concentrations at diffrent days at 15 cm depth is given in Table 2.

Table 2: Observed and predicted concentration (ppm) at different days

Time(days)	Predicted	Observed	% deviation
1	409.46	375	9.19
2	470.26	451	4.27
3	481.4	473	1.78
4	483.73	478	1.20
5	484.34	481	0.69
7	484.84	482	0.59
10	485.64	483	0.55

This table shows that the deveiaton in observed and predicted concentration is little higher at first day and after that it is lesser than 5 percent. Hence, dispersion coefficent determined by Gupta and Singh (1980) is most suitable for predicting movement of urea in flood irrigation condition in sitly loam soil. As the day passes, predicted concentration moved toward observed.

CONCLUSION

Hydrodynamic Dispersion Coefficient of urea in silty loam soil was found to be 0.00567 m^2 / hr. This value of dispersion coefficient may be used in equation (1) for estimation of the concentration of urea in groundwater by simply measuring the other parameters. The number of analytical solutions of Equation (1) is available in the literature, which may be used to estimate the concentration of urea in groundwater at any time and space domain.

REFERENCES

Anonymous. 2018 Annual Report 2017-18. Ministry of chemicals of Fertilizer Deptt of Fertilizer Govt. of India.

Bask P and Murty VVN 1979**.** Determination of hydraulic dispersion coefficients using "inverfc". *Journal of Hydrology* **41**: 43-48.

Bear J. 1961. Some experiments in dispersion. *Geophysical Research* **66**:2455-2467.

Bulusu KR, Pande SP. 1990. Nitrates a serious threat to groundwater pollution, *Bhu-Jal News* **5**:39–43

Guarda G, Padovan S and Delogu G. 2004. *Eur. J. Agron*. **21**: 181-192.

Gupta SK and Singh SR. 1980. Analytical solution for predicting solute movements and their interpretation in soil reclamation. *Journal of Hydrology* **45**: 133-148.

Kirkham D and Power Wl. 1972. Advanced soil physics. *Wiley-Inter sciencies*, New York, N. Y., 534pp.

Lal R and Stewart BA. 1994. Soil Processes and Water Quality-Advances in soil Science CRC Press Inc. Florida, pp. 409 – 427.

Pal R . 2002 . Hydrodunamic dispersion of urea in silty loam soil. Unpublished M. Tech Thesis submitted to GBPUAT, Pantangar.

Pal R, Sharma HC and Imtiyaz M. 2019. The analytical solution of transport equation for linearly decreasing urea concentration in shallow water table condition in irrigated field. *Jornal of Agrisearch* **6** (Special) 171-175.

Pandey RN and Gupta SK. 1984. Analysis of breakthrough curves: Effects of mobile and immobile pore volumes. *Aust. Journal of Soil Sci*. **22**: 23-30.

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