LEACHING STUDIES ON SOIL APPLIED INSECTICIDES

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ABSTRACT
Laboratory and field studies were conducted to assess the leaching potential of insecticides which are commonly used in vegetable cultivation viz., carbofuran, quinalphos, and phorate. The soil column studies made under laboratory conditions revealed the restricted movement of carbofuran and phorate up to 0-10 cm and were not detected in the leacheate. Quinalphos residues observed were high at 20-30 cm and were detected (0.5 ppb) in the leacheate. The mini-lysimeter studies conducted under simulated rainfall condition showed downward movement of insecticides and residues were detected in the leacheate collected on days '0' and 7 of applications. The leacheate collected after rainfall from leacheate collection unit fixed in field showed detectable residues of carbofuran, phorate and quinalphos.

Keywords: Soil insecticides, residues, glass column, Lysimeter, leaching

INTRODUCTION
Leaching through soil has been identified as a major cause for the occurrence of agrochemicals in groundwater. Though in some cases, accidental spills are responsible for contamination of ground water, in most cases conventional application causes leaching through soil (Ritter 1990). Many studies were conducted in temperate regions to assess the leaching potential of pesticides in field experiments (Bowman 1990; Gish et al. 1995; Johnson and Pepperman 1995). However, relatively few data were reported so far on pesticide fate under the specific climatic and pedological conditions in the tropics. Most of the residues of soil applied insecticides are restricted to root zone with low residues in the deep layers as in the case of carbofuran, phorate and quinalphos (Appaiah and Deshpande 1978; Awasthi et al, 1983). However, under field condition, transport of insecticides to lower layer was influenced by various factors like cultural operations, soil physical characters, rainfall pattern etc., Soil lysimeter is a tool in agricultural research to measure the movement and loss of inputs viz., chemical fertilizers, pesticides and their impact on ground water. Soil column and lysimeter studies were conducted in the laboratory and field in The Nilgiris district of Tamil Nadu to assess the fate of soil applied insecticides viz., carbofuran, phorate, quinalphos.

METHODOLOGY
1. Soil column studies
Leaching was assessed under laboratory conditions as per the method described by Lafleur (1976) using detachable glass column of 30 cm height. The individual units of 10 cm each were connected with rubber bands. The alfisol soil collected from Udagamandalam was sieved with 2 mm sieve and filled in the glass column with cotton plug at tapering end.

The insecticides (technical grade) were loaded on to the top of soil column @ 100 µg. and distilled water (200 ml) was added drop by drop @ 2-3 ml/hr and the leacheate was allowed to drain for 18 - 24 h. Extraction of leacheate and the soil from segments of 0-10, 10-20 and 20-30cm was carried out to assess the downward movement of insecticides.
2. Minilysimeter studies
A mini-lysimeter having dimensions of 32 cm height and 20 cm diameter was designed and fabricated using galvanised iron (G.I.). A spout provided at the top of the drum is useful to collect the runoff if any, during rainfall event. The soil sample/monolith of 30cm was collected as intact soil core using this G.I. drum from Horticultural Research Station, Udagamandalam, representing the area of study, by pressing the G.I. drum against hard soil with hammering. The soil core was kept intact by a muslin cloth tied at the base of the drum. Below aluminum funnel (20 cm diameter) was placed and directed into a glass container, for collecting the leacheate. The entire set up was placed on a stand (Plate 1, 2).

A rainfall simulator was designed at Department of Soil and Water Conservation, Agricultural Engineering College & Research Institute, Tamil Nadu Agricultural University, Coimbatore, to simulate the required rainfall intensity of the study area. The simulator consisted of a PVC frame and flexible PVC rubber tubes with pinholes fitted at equidistance. The setup was provided with water inlet and pressure gauge (Plate 2). The pressure and the height of the frame were adjusted to get the desired rainfall. An artificial rainfall of 5.0 cm/h was simulated representing the maximum intensity of the Nilgiris district. The amount of insecticide applied to soil column based on recommended dose was calculated using the formula given below (OECD, 2000). Each chemical was applied at recommended and double the recommended dose.

\[
\text{Amount applied (µg)} = \frac{A \times 10^9 \times (\text{µg/kg}) \times d^2 \times (\text{cm}^2) \times \Pi}{10^8 \times (\text{cm}^2/\text{ha}) \times 4}
\]

Where,
\[
A = \text{rate of application (kg/ha)}
\]
\[
d = \text{diameter of soil column}
\]
\[
\Pi = 3.14
\]

The formulated product was applied on to the dry soil column with slight racking and each treatment was replicated twice. The leacheate was allowed to drain by gravitational force and collected in a glass container placed at the base. The residues were extracted immediately. This was repeated after the lapse of one week of loading the insecticides on to soil column. The data on weather parameters used in this study were collected from Central Soil and Water Conservation Research and Training Institute (CSWCR&TI), Theettukkal, Udagamandalam.

3. Field leaching studies
For the studies under field condition, a leacheate collection unit was fabricated with 50 cm diameter and 30 cm height. Unit was provided with a slope at base and a perforated block on the inner side of outlet (Fig.1). The drum was filled with soil and fixed in the field where vegetables are grown regularly. The area of the exposed cylinder calculated \(r^2\) was 1962.5 cm2. The soil insecticides viz., carbofuran, quinalphos and phorate were applied at recommended doses (CPTHC, 1999) and each treatment was replicated twice. A teflon tube was provided at the outlet to collect the leacheate in a glass bottle. The rainfall of 105.6 mm distributed over 10 rainy days was received during the study period. The percolate was collected following rainfall events, throughout the study period of 30 days. The percolate samples in duplicate were pooled into one sample. After noting the percolate volume, samples were immediately extracted / stored at –20°C until extraction in the laboratory.

RESULTS AND DISCUSSION
In the present study results of soil column leaching made under laboratory condition showed maximum downward movement of quinalphos residues which was also detected (0.5 ng/lit) in the leacheate. No detectable residues of carbofuran and phorate were found in leacheate collected from soil columns (Table1). This is in conformity with the earlier reports made by Naitam and Sukhani (1996) and Kannathasan et al. (2001). However, the leacheate collected from minilysimeter showed detectable residues for all insecticides on 0 and 7 days after application (Table 2). The quantified residues of carbofuran, quinalphos and phorate were 39.0 and 59.0, 2.0 and 15.7, 0.3 and 0.10 ng/lit on ‘0’ and 7 days after application, respectively. Similarly, the leacheate unit fixed in the field under natural rainfall condition resulted in residue level of 880 ng/lit of carbofuran, 35ng/lit of phorate and 53ng/lit of quinalphos. The residues detected were high in first percolation events as influenced by preferential flow. This supporting evidence to the present study was made by Hall et al. (1989) and Laabs et al. (2002).
It is evident that results obtained in the laboratory may not always be applied to the field situation. Spatial variability or preferential flow phenomena have been hypothesized to be responsible for the inconsistencies between many laboratory and field studies (Jury and Flühler, 1992). Leaching studies using soil columns often indicate high retention of pesticides by the soil matrix, and not to be leached to groundwater to the extent found in monitoring studies.

Soil column studies on leaching exhibit higher retention of pesticides in soil matrix as influenced by compact, manual packing of sieved soil in glass column. The packed soil column lacks any routes like root channels, macropores or earthworm burrows favouring rapid vertical flow. In addition under laboratory condition known quantity of water (250 ml) is added drop wise without much impact on soil structure. Also the soil sample collected from Udagamandalam is characterized by high clay content (38.7%) in the surface soil than other soil fractions. The organic carbon content was observed to be high (6.8%). These physical characters might have resulted in the retention of insecticides in the soil column and were not detected in the leacheate. Parama et al. (1991) discussed the leaching rate of carbaryl and phorate based on these characters. Whereas there are many influencing factors in field like preferential flow which lead to the highest percolate concentration of pesticides right after application, due to infiltration of highly contaminated topsoil water (Hall et al., 1989). The high content of sand (43.0%) in top layer (0-23 cm) in the study area might have favoured the preferential flow of water along with contaminants. Earthworm burrows as a source of downward movement of atrazine, after the first rain, was demonstrated by Edwards et al. (1992). The detection of pesticides in lysimeter percolate provides direct evidence of pesticide transport in the soil water phase to subsoil regions.

| Table-1: Leaching and downward movement of insecticides - Soil column studies |
|----------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Height (cm)                           | Carbofuran (µg/g) | Per cent distribution | Quinalphos (µg/g) | Per cent distribution | Phorate (µg/g) | Per cent distribution |
| 0-10                                   | 58.80            | 64.83            | 10.27            | 13.88            | 53.00          | 66.67            |
| 10-20                                  | 24.20            | 26.68            | 15.28            | 20.65            | 26.50          | 33.33            |
| 20-30                                  | 7.70             | 8.49             | 58.44            | 78.98            | BDL            | -                |
| Leachate after 30 cm                   | BDL              | -                | 0.0005           | BDL              | -              |                  |
| Total                                  | 90.70            | 73.99            | 79.50            | -                |                 |                  |

| Table-2: Leaching and downward movement of insecticides–Minilysimeter Studies |
|--------------------------------------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Parameters                                                               | Carbofuran      | Phorate         | Quinalphos      | Fenvalerate     |
|                                                                         | RD              | 2X RD           | RD              | 2X RD           | RD              | 2X RD           |
| Quantity applied (µg/g)                                                  | 0.50            | 1.00            | 1.12            | 2.24            | 0.50            | 1.00            | 0.033           | 0.066           |
| Days after application                                                   | 0               | 0.039           | 0.002           | 0.005           | 0.0003          | 0.0004          | 0.0007          | 0.004           |
|                                                                         | (7.8)           | (5.1)           | (0.178)         | (0.22)          | (0.06)          | (0.04)          | (2.12)          | (0.61)          |
|                                                                         | 7               | 0.0111          | 0.019           | 0.0157          | 0.018           | 0.0001          | 0.0002          | 0.0013          | 0.002           |
|                                                                         | (2.22)          | (1.9)           | (1.4)           | (0.80)          | (0.02)          | (0.02)          | (3.94)          | (0.30)          |
Plate-1: Soil core collection unit

Plate-2: Minilysimeter-Leachate collection unit

Fig-1: Field Leachate collection Unit
REFERENCES


