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Research Article

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Degradation and Downward Movement of Lindane in Soil Under Cultivated Field Conditions

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Abstract

Transport of pesticides in soil is important because it determines the extent to which pesticides reach groundwater. Many investigators have studied in a qualitative manner the tendency of insecticides to move by leaching through the soil by developing a mathematical expression. Little attention has been given to the actual formulation of such a model particularly under cultivated field conditions. The investigations described in this paper presented quantitative data which has indicated the relative importance of the factors which must be considered in predicating pesticide movement under cultivable field conditions. The data on residues of lindane in soil under cropped conditions showed the highly persistence nature of the pesticide. The movement of lindane being a matter of inches rather than feet holds good with the present experimental findings though the experiment was carried out in a sandy loam soil with very little organic carbon and clay contents.

Keywords: Degradation; Downward movement; Field conditions; Lindane

Introduction

The accumulation of organ chlorine insecticides in soils has been reported with increasing frequencies since decades. The accumulation of these insecticides in soil, will in part depend upon the adsorption characteristics of these compounds and subsequent movement through soil profile [1]. Transport of these insecticides in soil is important because it determines the extent to which insecticides reach groundwater and transport may also be important for agricultural purpose: for soil applied insecticides some redistribution in the root zone is essential for good efficacy [2]. Information on the environment fate of pesticides has been generated mostly from studies in the temperate environment, because use of pesticides in agriculture and public health has been more extensive in temperate countries than in tropics and subtropics. However, a steady increase in use of pesticides, insecticides in particular, in tropics in recent years prompted studies on the fate and significance of pesticide residues in the tropical environment [3]. Surfaced applied or soil incorporated pesticides, after entering the agricultural system, may be translocated into plants, volatized into atmosphere, leached downward below the root zone, sorbed onto soil constituents, transported while being adsorbed on soil particles, or degraded to nontoxic molecules [4]. These pesticides also may affect the next crop, as well as non-target species. The transport of pesticides in soil, and their rate of disappearance from soil, is of considerable importance as down ward movement of pesticides may result in the contamination of ground water, yet the composite behavior of pesticides in sub-surface is almost impossible to determine accurately. Many investigators have studied in a qualitative manner the tendency of insecticides to move by leaching through the soil by developing a mathematical expression. Little attention has been given to the actual formulation of such a model particularly under cultivated field conditions [5]. The investigations described in this paper presented quantitative data which has indicated the relative importance of the factors which must be considered in predicating pesticide movement under cultivable field conditions.

Materials and Methods

A field experiment was conducted under tomato crop at Entomological Research Farm, Punjab Agricultural University, Ludhiana, Punjab, India during the year 2005-06 to study the rate of degradation and downward movement of lindane in soil. Tomato (var. Punjab Chhuhara) was transplanted in February following good agricultural practices that includes field preparation, intercultural operations like weeding, timely irrigation etc.

The important soil characteristics which were noted were clay content, organic matter content, pH (Table 1). Water solubility, molecular weight, polarity and biodegradability were defined as the principal pesticide properties of importance.

Lindane (99.9% gamma isomer of 1, 2, 3, 4, 5, 6 hexachloro cyclohexane) stable to light, air, acid and temperature up to 180°C with molecular weight of 290.8 and water solubility of 7.3 mg lit^{-1} at 25°C was used as an experimental insecticide. Environmental factors which must influenced the degradation of insecticides are temperature, rainfall and relative humidity are presented in (Table 2).

The field experiment was set up to study the rate of degradation and downward movement of lindane in soil. PVC tubes (18” × 4”) were vertically pushed into the field soil without disturbing the soil texture. One kg of top layer soil form each tube was removed and mixed with

Soil characteristics	
Texture	Sandy loam
Sand (%)	15.1
Silt (%)	79.7
Clay (%)	5.2
pH	7.5
Organic Carbon (%)	0.18

Table 1: Properties of Field Soils used for the experiment.

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Month	Maximum* Temp. (°C)	Minimum* Temp. (°C)	Relative Humidity* (%)	Rainfall* (mm)
February	18.7	8.5	79	47.4
March	25.8	13.6	72	42.2
April	34.6	16.6	45	6.1
May	37.9	22.2	43	Nil
June	39.3	26.5	49	48.1

*Mean of the month

Table 2: Weather conditions during the experimental period (Feb 2005 to June 2005).

lindane (Kanodane 20 EC) to give concentrations of 100, 200 and 500 mg a.i. kg^{-1} of soil. The scheduled cultural practices like weeding, irrigation, earthing up were carried out. For residue analysis samples were taken from depths of 0-15, 15-30 and 30-45 cms up to 90 days to study the dissipation pattern with timely movement of lindane under field conditions whereas samples from the depths of 0-15, 15-30, 30-45, 45-60, 60-75 and 75-90 cms at 150 days (after the crop was harvested) were taken in order to study the rate of downward movement of lindane in soil under a cropped area.

Fifty-gram soil sample was dipped in 100 ml mixture of methanol and water (2:1 v/v) for overnight. The contents were filtered into one litre separatory funnel, diluted with 500 ml of 5 per cent sodium chloride solution and partitioned twice into hexane (100+50 ml, each) separately. The combined hexane layers were concentrated and transferred to hexane for estimation by gas liquid chromatography (GLC) equipped with electron capture detector (ECD) and a glass column (1 m × 2 mm i.d) packed with ready to use 1.5% SP-2250+1.95% SP2401 on 80-100 mesh supelco port. The operating conditions of GLC were as follows: detector temperature: 270°C, oven (column) temperature: 200°C, injector temperature: 240°C and carrier gas (N_2) flow rate: 3.5 kg cm^{-2}. Under these operating conditions, lindane gave peak with retention time of 0.97 minutes. The average recoveries of lindane from soil sample spiked with concentrations ranging from 0.2, 0.5 and 1.0 mg kg^{-1} were found to be more than 80 percent.

Results and Discussion

Degradation of lindane under field conditions

The quantitative estimates of lindane residues in soils at different depths drawn at varying intervals, after applications @ 100, 200 and 500 mg a.i. kg^{-1} of soil are presented in tables 3 to 5. The residues of lindane in control were found to be below the detectable limit of 0.01 mg kg^{-1}.

The mean initial deposit of lindane in 0-15 cm layer was found to be 104.51 mg kg^{-1}, which dissipated to a mean level of 29.09 mg kg^{-1}, thus showing a loss of 72.16 percent after 30 days of application. After 150 days of application, the residues were found to be dissipated by 99.75 percent (Table 3).

Following application of lindane @ 200 mg a.i. kg^{-1} of soil, the mean initial deposit of 194.24 mg kg^{-1}, were found to be dissipated by 80.46 percent, after 30 days of application. The levels of lindane residues were found to be 1.99 mg kg^{-1} after 150 days of application, thereby, showing a degradation of 98.97 percent (Table 4).

When lindane was applied at the dose of 500 mg kg^{-1}, the mean initial deposit of 438.52 mg kg^{-1} was dissipated to 145.63 mg kg^{-1} after 30 days of application, thus showing a loss of 66.79 percent. Residues levels, at the end of 150 days were 4.44 mg kg^{-1} which were only 1.01 percent of the initial deposit (Table 5).

Downward movement of lindane in soil

The quantitative estimation of residues of lindane at different depth drawn at 150 days (crop period) after application of insecticide are presented in table 3 to 5. The data on residues of lindane in soil under cropped conditions show that there was no downward movement of lindane though the experiment was carried out in a sandy loam soil with very little organic carbon and clay content. This results deviates

Days after treatment	Depths (cms)	Mean ± S.D.	Per cent dissipation
0	0-15	104.51± 0.69	
7	0-15 15-30 30-45	78.53 ± 0.70 BDL BDL	24.86
15	0-15 15-30 30-45	37.15 ± 1.24 BDL BDL	64.45
30	0-15 15-30 30-45	29.01 ± 0.30 BDL BDL	72.16
45	0-15 15-30 30-45	6.51 ± 0.62 BDL BDL	93.77
60	0-15 15-30 30-45	4.99 ± 0.12 BDL BDL	95.22
90	0-15 15-30 30-45	1.51 ± 0.02 BDL BDL	98.55
150	0-15 15-30 30-45 45-60 60-75 75-90	0.26 ± 0.01 BDL BDL BDL BDL BDL	99.75

$T_{½}$ = 17.10 days; BDL= <0.01 mg kg^{-1}

Table 3: Residues of lindane (mg kg-1) in soil following its application @ 100 mg kg-1 of soil.

Days after treatment	Depths (cms)	Mean ± S.D.	Per cent dissipation
0	0-15	194.24 ± 2.66	
7	0-15 15-30 30-45	127.93 ± 1.29 BDL BDL	34.75
15	0-15 15-30 30-45	73.04 ± 0.54 BDL BDL	62.40
30	0-15 15-30 30-45	37.96 ± 0.97 BDL BDL	80.46
45	0-15 15-30 30-45	17.61 ± 0.68 BDL BDL	90.93
60	0-15 15-30 30-45	7.36 ± 0.22 BDL BDL	96.21
90	0-15 15-30 30-45	4.98 ± 0.11 BDL BDL	97.44
150	0-15 15-30 30-45 45-60 60-75 75-90	1.99 ± 0.03 BDL BDL BDL BDL BDL	98.97

$T_{½}$ = 22.46 days; BDL= <0.01 mg kg^{-1}

Table 4: Residues of lindane (mg kg^{-1}) in soil following its application @ 200 mg kg^{-1} of soil.

Days after treatment	Depths (cm)	Mean ± S.D.	Per cent dissipation
0	0-15	438.52 ± 2.78	
7	0-15 15-30 30-45	329.48 ± 1.64 BDL BDL	24.86
15	0-15 15-30 30-45	182.29 ± 0.97 BDL BDL	58.42
30	0-15 15-30 30-45	145.63 ± 2.28 BDL BDL	66.79
45	0-15 15-30 30-45	76.57 ± 0.22 BDL BDL	82.54
60	0-15 15-30 30-45	25.85 ± 0.21 BDL BDL	94.10
90	0-15 15-30 30-45	11.13 ± 0.63 BDL BDL	97.46
150	0-15 15-30 30-45 45-60 60-75 75-90	4.44 ± 0.35 BDL BDL BDL BDL BDL	98.99

$T_{½}$ = 21.66 days; BDL= <0.01 mg kg^{-1}

Table 5: Residues of lindane (mg kg^{-1}) in soil following its application @ 500 mg kg^{-1} of soil.

from the equation:-

$$K_{OC} = \frac{K_d}{F_{OC}}$$

(K_{OC}=soil organic carbon sorption coefficient; K_d=soil sorption partition constant and F_{OC}=organic carbon fraction of the specific soil).

The soil organic matter is the only sorbing material in the solid phase and that soil organic matter in all soils has the same affinity for solutes. However, soil/water/pesticide systems exhibit much more complex behaviour under field conditions than that of mathematical model developed in laboratory conditions. More polar solutes, surfaces of other materials in soils can also become important sorbents, particularly in soils where the organic matter fraction is low may holds good in this case [6-8]. The important soil parameters in the transport of pesticide is the sorption coefficient. This was measured in laboratory experiments in which a suspension of soil was shaken for about half a day or a long term sorption process. But under field conditions, sampling dates 5 months (total crop period) after application of pesticides associated with irrigation at regular intervals resulted in a considerable effect on the transport of pesticides. Extreme sorption is associated with extreme persistence [9-11]. May be one of the reason regarding the movement of lindane in soil under field conditions. The experimental findings of Key and Elrick [1] regarding the failure of mathematical model to predict lindane elution for different low rate and conclusion made by him that under field conditions it is expected that the leaching of lindane will be limited, the movement being a matter of inches rather than feet holds good with the present experimental findings. However, to know accurately the degree of sorption of a specific pesticide in a specific soil, the approach is still empirical- a measurement must be made.

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References

1. Kay BD, Elrick DE (1967) Adsorption and movement of lindane in soils. Soil Sci 104 (5): 314-322.
2. Boesten JJTI, Van der Pas LJT, Smelt JH (1989) Field test of a mathematical model for non-equillibrium transport of pesticides in soil. Pestic Sci 25: 187-203.
3. Ramanand K, Panda, S, Sharmila M, Adhya TK, Sethunathan N (1998) Development and Acclimatization of cabofuran degradaing soil enrichment cultures at different temperatures. J Agric Food Chem 36: 200-205.
4. Singh G, Spencer WF, Genuchten MTV, Kookana RS (1992) Predicting Pesticide Transport in Soil. Pestic Res J 4: 1-10.
5. King PH, Mc Carty PL (1968) a chromatographic model for predicting pesticide migration in soils. Soil Sci 106 (4): 248-261.
6. Helling CS, Kearney PC, Alexander M (1971) Behaviour of pesticides in soils. Adv Agron 23: 147-239.
7. Karickhoff SW (1984) Organic pollutant sorption in aquatic systems. Hydraul Engng 110: 707-735.
8. Hance RJ (1969) Influence of p^H, exchangeable cation and the presence of organic matter on the adsorption of some herbicides by montmorillonite. Canad J Soil Sci 49: 357-364.
9. Walker A, Welch SJ (1989) the relative movement and persistence in soil of chlorsulfuron, metsulfuron-methyl and trisulfuron. Weed Res 29: 337-383.
10. Gamerdinger AP, Achin RS, Traxler RW (1997) Approximating the impact of sorption on biodegradation kinetics in soil-water systems. Soil Sci Soc Am J 61: 1618-1626.
11. Guo L, Wagenet RJ, Jury WA (1999) Adsorption effects on kinetics of aldicarb degradation: equillibrium model and application to incubation and transport experiments. Soil Sci Soc Am J 63: 1637-1644.

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