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Fate of ^{14}C Nitrofen in Rice Paddy Ecosystem

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Metcalf et al. (1971) introduced the model ecosystem technique for the evaluation of pesticide biodegradability and ecological magnification. In this technique an aquarium tank accomodates the terrestrial and aquatic habitats. Plants, phytophagous insects, decomposer invertebrates, microorganisms and predaceous fishes are included in the system. The radiolabelled pesticide is added to the tank and the fate of the pesticide and its degradation products can be followed through the system. Earlier, the model system contained sand, water, plants and animals (Metcalf 1974) but subsequent studies incorporated soil in the ecosystem thus enlarging the scope and value of the technique (Isensee and Jones 1975; Isensee et al. 1976). Recently Miyamoto et al. (1985) have critically evaluated model systems and underlined their importance for studies on the degradation of pesticides. We have followed the fate of ^{14}C nitrofen (2,4-dichlorophenyl 4'-nitrophenyl ether) in rice paddy ecosystem and the results are reported here.

MATERIALS AND METHODS

The ecosystem was established in all glass aquarium tank (18" x 10" x 12"). The tank was divided into unequal compartments using a glass partition. The larger compartment was filled with 10 Kg black clay soil (Trombay soil pH 7.2; OM 2.44%). The tank was filled with 20 liters of water and the level was maintained same throughout the period of experiment. The tanks were kept in outdoor conditions. Ten day old rice seedlings (*Oryza sativa* TR 21) were transplanted in each of the two experimental tanks and one control tank. Fish (*Gambusia*) and alga (*Chara*) were introduced into the ecosystem. Snails already present in the soil were used.

^{14}C nitrofen (sp. activity 14.2 μCi/mg) was mixed with unlabelled nitrofen (Tok E-25) in acetone and applied to the tanks at the rate of 10 lit/ha on surface area basis. The tank which received only acetone served as control. The samples of fish, rice plants, soil, water, snail and algae were collected at intervals of

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Table 1. Recovery of ^{14}C residues in rice paddy ecocystem treated with ^{14}C-nitrofen.

Distribution of ^{14}C residues*

	Time after treatment (days)									
	10		20		30		40		120	
	Extractable	Bound	Extractable	Bound	Extractable	Bound	Extractable	Bound	Extractable	Bound
Fish	0.05	0.01	0.03	0.01	0.04	0.02	0.01	0.01	n.d.	n.d.
Snail	0.04	0.06	0.03	0.01	0.02	0.03	0.01	0.02	n.d.	n.d.
Algae	0.15	0.18	0.04	0.09	0.02	0.07	tr	0.01	tr	0.01
Plant	0.03	n.d.	0.04	0.08	0.02	n.d.	tr	n.d.	n.d.	n.d.
Water	10.51	-	9.06	-	4.35	-	3.80	-	0.40	-
Soil	26.83	63.29	23.72	29.21	6.16	29.46	2.97	22.92	0.75	4.91
Total	37.61	63.44	32.92	29.40	10.61	29.58	6.79	22.96	1.15	4.92
TOTAL (Extractable & Bound residues)	101.05		62.32		40.19		29.75		6.07	

* Total ^{14}C recovered expressed as percent of the total ^{14}C applied to the tank at the beginning of the experiment.
n.d. - non-detectable. tr - trace (below 0.01%).

10, 20, 30, 40 and 120 days. The soil, algae, rice plants, fish and snail samples were extracted with methanol (extractable residues) using Soxhlet apparatus, and aliquots of solvent extracts were directly counted in Packard Liquid Scintillation spectrometer 3255. The samples after solvent extraction were air-dried and subjected to oxidation using Harvey Biological Material oxidizer and the ^{14}C radioactivity recovered in the form of $^{14}CO_2$ represented unextractable or bound residues. Rice plants collected at 10 and 20 days were subjected to autoradiography using Indu X-ray film.

RESULTS AND DISCUSSION

That nitrofen undergoes rapid degradation is evident from total ^{14}C residues recovered at various intervals of time (Table 1). At 10 days 101.05% of ^{14}C residues could be detected whereas at 120 days the recovery was only 6.07%. This loss may be due to various factors like volatilization, degradation, mineralization etc. of the parent compound and/or its metabolites. Most of the loss in residues occurred during initial stages of rice paddy ecosystem.

Both extractable and bound residues were low in fish, snail and algae at any of the time intervals sampled. This indicated that residues of nitrofen do not bioaccumulate. Because of low levels of ^{14}C residues present in the extracts no attempt was made to fractionate and identify the parent compound and its metabolites. The radioactivity in flood water decreased with time; thus from 10.51% at 10 days, it decreased to 0.40% at 120 days. Rice plants showed negligible radioactivity and this was corroborated by autoradiographic studies of rice plants. Autoradiography of rice plants grown in tank for 10 and 20 days after ^{14}C nitrofen treatment, did not show any evidence of uptake.

Of the many components of rice paddy ecosystem only soil showed considerable ^{14}C residues in both extractable and bound fractions. At 10 days soil showed total residues of 90.12% which decreased to 5.66% at the end of 120 days. Bound residues constituted the major share of ^{14}C residues in soil. The bound residues constituted 63.29% of the total ^{14}C residues at 10 days which was subsequently decreased to 4.91% at 120 days. It is likely that amino nitrofen, a degradation product of nitrofen may have contributed to bound residue formation. Bound residues decreased rapidly after 40 days of incubation. Evidently the bound residues are released over a period of time and the extractable residues formed in turn gets immediately degraded so that very little of extractable residues remain. Nitrofen was shown to be degraded in soil and many microbial isolates capable of degrading nitrofen were obtained (Lee et al. 1980).

The results obtained here are in variance to the observations of Lee et al. (1976) who worked on the fate of three dichlorophenyl nitrophenyl ether herbicides including nitrofen. Their observations showed that nitrofen bioaccumulated in tissues of algae, snail, mosquito and fish. However, their model system

included the use of standard reference water and sand, and the tanks were kept in environmental plant growth chamber at standardized conditions. In contrast, in our experiments water and soil were obtained from field and the tanks were kept in outdoor field conditions under cages. From the enhanced reduction of ^{14}C residues under our experimental set up, it is obvious that nitrofen was rapidly degraded under semi-tropical conditions. These observations strongly suggest the need for studying the fate of pesticides in rice paddy ecosystem under simulated outdoor field conditions.

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