Effect of moisture regimes and pesticides of different biodegradability on transformation of different forms of inorganic and organic N in a dominant soil series of West Bengal

Arunava Das¹, Niladri Paul^{2*} and Dipankar Saha³

¹Office of the Assistant Director of Agriculture, Bankura, Government of West Bengal, India.
 ²Department of Soil Science and Agricultural Chemistry, College of Agriculture, Tripura, India.
 ³Department of Soil Science & Agricultural Chemistry, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, India.

*Corresponding author: nilupaul82@rediffmail.com

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Abstract

A laboratory experiment was conducted to study the effect of pesticides of different biodegradability on changes in inorganic and organic forms of N in soil maintained under two different moisture regimes. Results revealed that irrespective of pesticides and N treatment, comparatively higher amount of available N is recorded in waterlogged then the soil kept at 60% MHC. Addition of pesticides at lower dose affects the transformation process of organic N in soil. Irrespective of pesticide treatment, in general, hydrolysable NH_4^+ -N decreased but on the other hand amino acid N increased in soil. Again, the intensity of decrease or increase is more in waterlogged than the soil maintained under 60% of the MHC.

Highlights

- The changes in different N forms in comparison to different moisture regimes in soil.
- Affectivity of pesticides on different N forms is evaluated in both waterlogged and 60% MHC conditions.

Keywords: Moisture regimes, pesticides, hydrolysable NH_4^+ -N and amino acid N.

Nitrogen is one of the major nutrients required by plant for growth and metabolic activities, mostly taken from the soil. N present in soil generally comes from natural sources and applied fertilizers. Both types of N are important for growing plants. Introduction of high yielding varieties of crops has drawn further attention for efficient use of N-fertilizers in particular. The amount of N supplied naturally during a cropping season is influenced by many factors (Jenny and Raychoudhuri 1960; Brady and weil 2007; Liu *et al.* 2007). Environmental conditions as well as management practices change the liberation process and quality of soil N released. The efficient utilization of N from native or applied sources depends on the clear understanding of different transformation processes in soil (Nyiraneza and Snapp 2007; Srivastava and Singh 1996). Management practices do influence the N transformation processes in soil may proceed simultaneously and



they interact in several ways (Aulakh *et al.* 2000, 2001a, 2001b). It is therefore necessary to understand all the processes involved in totality to get a clear picture of N transformation in soil.

Mineralization of N in soil varies due to various factors like soil characteristics, different management practices, climate, cropping etc. As it is now well established that native soil N transformation is different from that of fertilizer N, it is necessary to understand the N transformation process, which ultimately influence the N uptake by plants.

Our knowledge on the interchange of inorganic and organic N in soil was mostly obtained from studies that measure only the net result of two opposite forces, namely immobilization and mineralization. But very few attempts have so far been made to relate mineralization of N with simultaneous decrease of different forms of organic N present in the soil under different micro environmental conditions.

Pesticides play a vital role on different processes of N-transformation in soils. The degraded products of pesticides as well as persistence of pesticides in soil may influence different N-transformation processes occurring in soils in different ways. Sometimes the effect of pesticides is injurious to certain group of organisms which in turn is beneficial to others. Microorganisms responsible for nitrification is sometimes adversely affected, quite interestingly enough, however, ammonification is often benefited by pesticides' use. Pesticides' use to protect standing crop is now a regular practice to farmers. Soil application of pesticides causes an accumulation of the degraded products in top soil (Elimache et al. 2012), the sphere of maximum microbial activities. However, conflicting reports (Gaur 1990; Moorman 1989; Paul et al. 2010; Singh and Prasad 1991) are available regarding the effect of pesticide on microbial activities in soils. Different N transformation processes are influenced due to soil application of pesticides (Syversen and Haarstad 2005). Both negative (Prabhu and Raut 2011; Kar 1990; Martinez-Toledo et al. 1992; Meghraj et al. 1988) and positive (Balanger *et al.* 1985; Jana *et al.* 1987; Kucuk *et al.* 2012) response on biological N fixation are reported by

number of workers due to application of pesticides in soil. Microorganisms responsible for nitrification are sometimes adversely affected quite interestingly enough; however, ammonification is often benefited by pesticides' use (Edward 1966; Okamoto *et al.* 1999). Limited information is available regarding the effect of pesticides on distribution of different fractions of inorganic and organic N in soils.

Moisture is an important factor for the growth of microorganisms and in controlling the rate of organic matter decomposition. Although presence of moisture above a certain level is not congenial for microbial activity (Chen *et al.* 2012) indirectly it is important, because higher the moisture present in soil lesser the oxygen available for microbial growth. Standford and Epstein (1974) reported a near linear relationship between N mineralization and soil water content in the range of 1/3 to 15 bar. The present investigation was, therefore, conducted to study the changes of different forms or inorganic and organic N in soil treated with pesticides of different biodegradability and maintained under different moisture regimes.

Materials and Methods

A composite soil sample was collected from a cultivated field (0 -15 cm depth) of a dominant soil series of Chakdaha in the district of Nadia, West Bengal. The soils were air dried ground and passed through 0.5 mm. sieve. The relevant physical and chemical characteristics of the soil are presented in Table 1.

Each of 10g air dried soil was taken in 100 ml beaker for the experimentation purpose. Two doses of Chlorinated hydrocarbon pesticide (Endosulfan) and Organophosphorus pesticide (Chlorpyriphos) at 0.5 kg a.i. ha⁻¹ and 1 kg a.i. ha⁻¹, respectively and two levels of moisture viz. 60% of the Moisture holding capacity (MHC) of the soil and waterlogged condition were maintained for incubation study. N-treatment was included in the study at 100 mg N kg⁻¹ through (NH₄)₂SO₄. All the treatments were replicated thrice.

Paramet	Characteristics			
	Sand (%)	22.07		
Mechanical Separates	Silt (%)	33.88		
	Clay(%)	44.05		
Moisture holding capaci	ity (%)	49.45		
Bulk density (g c.c ⁻¹)		1.22		
рН		7.17		
Electrical conductivity (0.35			
Cation exchange capaci soil]	11.39			
Oxidisable organic carb	on (%)	0.79		
Exchangeable NH_4^+ (mg	111.194			
Soluble NO ₃ ⁻ (mg kg ⁻¹)		52.595		
Available N (mg kg ⁻¹)		163.789		
Available Phosphorus (k	68.08			
Exchangeable potash (k	g ha ⁻¹)	334.58		
Nomenclature accord classification	Aeric Endo Aquepts			

Table 1. General characteristics of the soil used for the investigation

Treatment adopted for the experiment may be written as follows:

 T_0 = Soil kept at 60% of M.H.C.

 $T_1 = T_0 + N$ at 100 mg kg⁻¹

 T_2 = Soil kept under waterlogged condition

 $T_3 = T_2 + N$ at 100 mg kg⁻¹

 $T_4 = T_0 + Endosulfan at 0.5mg a.i. kg^{-1}$

 $T_5 = T_4 + N$ at 100 mg kg⁻¹

 $T_6 = T_2$ + Chlorpyriphos at 0.5 mg a.i. kg⁻¹

 $T_7 = T_6 + N \text{ at } 100 \text{ mg kg}^{-1}$

 $T_8 = T_0 + Endosulfan at 1mg a.i. kg^{-1}$

 $T_9 = T_8 + N \text{ at } 100 \text{ mg kg}^{-1}$

$T_{10} = T_2 + Chlorpyriphos at 1mg a.i. kg^{-1}$

$T_{11} = T_{10} + N$ at 100 mg kg⁻¹

Soils were allowed to incubate at room temperature $(30 \pm 2)^{\circ}$ C for a period of 60 days. Four separate sets were maintained for laboratory analysis on 0th, 15th, 30th and 60th day of incubation. Samples of all sets were identically collected for analysis of exchangeable NH₄⁺, soluble NO₃⁻, total hydrolysable organic N, hexosamine – N, hydrolysable organic NH₄⁺ -N and amino acid - N. Loss of moisture due to evaporation was replenished by the addition of distilled water on every alternate day by difference in weight.

2(M) KCl solution was employed for extraction of exchangeable NH_4^+ and soluble NO_3^- - N and were determined by the method of Bremner and Keeney (1966). Exchangeable NH_4^+ soluble NO_3^- is considered as available N in the text. Different forms of organic N were estimated by the method of Stevenson (1996).

Results and Discussion

Irrespective of moisture regimes, the amount of exchangeable NH⁺ in soil tended to decrease with increase in the period of investigation (Table 2). This trend of results is observed both in presence and absence of inorganic N. The decrease in exchangeable NH₄⁺ is due to loss of N through volatilization (Broadbent and Tusneem 1971) or due to immobilization of N into organic forms. However, in presence of both endosulfan and chloropyriphos, the amount of exchangeable NH⁺ tended to decrease upto 15th day, thereafter showed an increase on 30th day followed by decrease upto 60th day of incubation. This trend of result is observed irrespective of moisture regimes and inorganic N additions. The sudden increase in exchangeable NH₄⁺ on 30th day of incubation is perhaps due to spurt in activities of ammonifying bacteria (Das 1997). Data further reveal that irrespective of moisture regimes and pesticide addition, comparatively higher amount of exchangeable NH₄⁺ is accumulated in the N-treated over the untreated system throughout the period of investigation (Table 2). This is the effect of N-addition. In general, comparatively higher amount of



Turaturata	M	N 6	Incubation period		period (Days	(Days)	
Ireatments	Moisture regimes	N-Iertilization	0	15	30	60	
	600/ of MUC	-	56.73	49.04	eriod (Days 30 41.13 75.94 41.13 69.62 112.32 148.71 175.92 186.67 99.67 147.13 129.72 161.36 120.19 169.27 100.03 169.27 100.03 169.27 100.03 169.27 100.144 0.0144 0.0144 0.0144 0.0246 0.027 1.3983 1.3983 1.1417 1.9777	34.8	
01	60% 01 MHC	+	143.96	82.26	75.94	49.04	
5011	Watarila and	-	56.93	44.29	41.13	41.13	
	waterlogged	+	137.12	82.36	69.62	52.2	
	600/ of MUC	-	52.2	50.62	30 30 41.13 75.94 41.13 69.62 112.32 148.71 175.92 186.67 99.67 147.13 129.72 161.36 120.19 169.27 100.03 169.27 100.13 159.79 124.98 142.38 0.0176 0.0144 0.0246 0.0246 0.0202 0.0349 0.9889 0.8073 1.3983 1.1417 1.9777	39.55	
Soil + Endosulfan at 0.5	00% 01 MHC	+	147.12	105.97	148.71	41.3	
mg a.i kg-1	Watarlagaad	-	64.53	53.78	175.92	96.56	
	wateriogged	+	148.73	83.51	186.67	117.06	
	600/ of MUC	-	58.54	77.52	Beriod (Days 30 41.13 75.94 41.13 69.62 112.32 148.71 175.92 186.67 99.67 147.13 129.72 161.36 120.19 169.27 100.03 169.27 100.16 159.79 124.98 142.38 0.0176 0.0144 0.0246 0.0246 0.0202 0.0349 0.8073 1.3983 1.1417 1.9777	50.62	
Soil + Chloropyriphos	60% 01 MHC	+	137.63	80.35	147.13	58.53	
at 0.5 mg a.i kg-1	Watarlagaad	-	72.26	60.12	129.72	83.83	
	waterlogged	+	145.09	Incubation period (Days) 15 30 49.04 41.13 3 82.26 75.94 4 44.29 41.13 4 82.36 69.62 3 50.62 112.32 3 105.97 148.71 4 53.78 175.92 9 83.51 186.67 11 77.52 99.67 5 80.35 147.13 5 60.12 129.72 8 66.44 161.36 9 93.34 120.19 4 146.61 169.27 6 44.29 100.03 5 80.68 169.27 7 66.44 109.16 3 121.81 159.79 7 56.95 124.98 8 0.0375 0.0176 0 0.0308 0.0144 0 0.0334 0.0246 0 0.0434 0.0202<	96.5		
	600/ of MUC	-	50.62	93.34	120.19	41.13	
Soil + Endosulfan at 1.0	00% 01 MHC	+	149.68	146.61	ation period (Days) 5 30 15 30 104 41.13 .26 75.94 .29 41.13 .36 69.62 .62 112.32 5.97 148.71 .78 175.92 .51 186.67 .52 99.67 .35 147.13 .12 129.72 .44 161.36 .34 120.19 5.61 169.27 .44 109.16 1.81 159.79 .44 109.16 1.81 159.79 .95 124.98 .972 142.38 .955 0.0176 .908 0.0144 .9308 0.0144 .9308 0.0246 .934 0.0202 .954 0.0349 .928 0.8073 .9328 0.8073 .9328 0.8073	64.47	
mg a.i kg-1	Watarlagaad	-	55.42	Incubation period (Days) 15 30 49.04 41.13 6 82.26 75.94 44.29 41.13 2 82.36 69.62 50.62 112.32 2 105.97 148.71 3 83.51 186.67 4 77.52 99.67 3 80.35 147.13 5 60.12 129.72 9 66.44 161.36 2 93.34 120.19 8 146.61 169.27 9 66.44 109.16 8 121.81 159.79 4 56.95 124.98 1 129.72 142.38 6 0.0375 0.0176 4 0.0308 0.0144 6 0.0534 0.0246 6 0.0534 0.0246 6 0.0534 0.0246 6 0.0569 1.3983	50.62		
	wateriogged	+	117.03	80.68	and 30 41.13 75.94 41.13 69.62 112.32 148.71 175.92 186.67 99.67 147.13 129.72 161.36 120.19 169.27 100.03 169.27 100.14 0.0176 0.0144 0.0246 0.0246 0.0246 0.0246 0.0246 0.0246 0.0246 0.0246 0.0349 0.8073 1.3983 1.3983 1.3983 1.417 1.9777	79.28	
	(00/ - FMILC	-	149.08 140.01 169.27 55.42 44.29 100.03 117.03 80.68 169.27 69.93 66.44 109.16 142.38 121.81 159.79 72.84 56.95 124.98	34.83			
Soil + Chloropyriphos	60% 01 MHC	+ 142.38 121.81			159.79	72.77	
at 1.0 mg a.i kg-1	Watarlagaad	-	72.84	56.95	eriod (Days 30 41.13 75.94 41.13 69.62 112.32 148.71 175.92 186.67 99.67 147.13 129.72 161.36 120.19 169.27 100.03 169.27 100.03 169.27 109.16 159.79 124.98 142.38 0.0176 0.0144 0.0246 0.0349 0.8073 1.3983 1.3983 1.1417 1.9777	87.01	
	waterlogged	+	148.41	129.72	eriod (Days 30 41.13 75.94 41.13 69.62 112.32 148.71 175.92 186.67 99.67 147.13 129.72 161.36 120.19 169.27 100.03 169.27 100.03 169.27 100.03 169.27 100.144 0.0144 0.0144 0.0144 0.0144 0.0246 0.0349 0.8073 1.3983 1.3983 1.1417 1.9777	88.53	
		Soils(S)	0.0176	15 30 49.04 41.13 82.26 75.94 44.29 41.13 82.36 69.62 50.62 112.32 105.97 148.71 53.78 175.92 83.51 186.67 77.52 99.67 80.35 147.13 60.12 129.72 66.44 161.36 93.34 120.19 146.61 169.27 44.29 100.03 80.68 169.27 66.44 109.16 121.81 159.79 56.95 124.98 129.72 142.38 0.0375 0.0176 0.0308 0.0144 0.0308 0.0144 0.0308 0.0144 0.0308 0.0144 0.0314 0.0202 0.0434 0.0202 0.0434 0.0202 0.0328 0.8073 0.0328 0.8073 </td <td>0.0176</td>	0.0176		
		Nitrogen(N)	Description Description 0 15 30 56.73 49.04 41.13 143.96 82.26 75.94 56.93 44.29 41.13 137.12 82.36 69.62 52.2 50.62 112.32 147.12 105.97 148.71 64.53 53.78 175.92 148.73 83.51 186.67 58.54 77.52 99.67 137.63 80.35 147.13 72.26 60.12 129.72 145.09 66.44 161.36 50.62 93.34 120.19 149.68 146.61 169.27 69.93 66.44 100.03 117.03 80.68 169.27 69.93 66.44 109.16 142.38 121.81 159.79 72.84 56.95 124.98 (S) 0.0176 0.0375 0.0176 M 0.0246 0.0534	0.0144			
		Moisture(M)	0.0144	0.0308	30 30 41.13 75.94 4 41.13 69.62 1 112.32 1 1 175.92 9 1 175.92 9 1 175.92 9 1 175.92 9 1 175.92 9 1 175.92 9 1 175.92 9 1 186.67 1 99.67 9 147.13 9 1 1 120.19 4 1 1 169.27 0 1 1 100.03 1 1 1 159.79 1 1 1 142.38 3 1 1 0.0176 0 0 0 0.0246 0 0 0 0.0349 0 0 0 0.08073 0 0 0 0.08073 0 0	0.0144	
	Endosulfan	SXN	0.0246	0.0534		0.0246	
		SXM	0.0246	0.0534	0.0246	0.0246	
		NXM	0.0202	0.0434	0.0202	0.0202	
$(\mathbf{D}, (\mathbf{D}, 0, 0.5))$		SXNXM	0.0349	0.0754	0.0349	0.0349	
CD (P=0.05)		Soils(S)	0.0185	0.0402	0.9889	0.7657	
		Nitrogen(N)	0.0152	0.0328	0.8073	0.6252	
		Moisture(M)	0.0152	0.0328	0.8073	0.6252	
	Chloropyrophos	SXN	0.0264	0.0569	1.3983	1.0827	
		SXM	0.0264	0.0569	1.3983	1.0827	
		NXM	0.0214	0.0463	1.1417	0.8842	
		SXNXM	0.0372	0.0804	6 69.62 112.32 112.32 97 148.71 8 175.92 1 186.67 2 99.67 5 147.13 2 129.72 4 161.36 4 120.19 51 169.27 9 100.03 8 169.27 9 100.03 8 169.27 9 100.03 8 169.27 9 100.03 8 169.27 4 109.16 31 159.79 5 124.98 72 142.38 75 0.0176 98 0.0144 98 0.0144 94 0.0246 94 0.0246 94 0.0349 92 0.9889 98 0.8073 99 1.3983 99 1.3	1.5314	

Table 2. Effect of pesticides and moisture regimes on changes in the amount (mg kg⁻¹) of exchangeable NH_4^+ in soil treated with or without inorganic N



Turetar	M	N. C	Incubation perio		period (Days)	od (Days)		
Treatments	Moisture regimes	N-Tertilization	0	15	30	60		
		-	41.13	60.12	69.54	50.62		
G 1	60% 01 MHC	+	34.8	73.07	83.9	52.2		
Waterlogged	W7 / 1 1	-	39.55	34.8	31.64	72.77		
	wateriogged	+	53.79	87.01	55.37	109.16		
		-	30.06	58.54	99.67	37.37		
Soil + Endosulfan at 0.5	60% of MHC	+	30.06	71.19	102.82	41.14		
mg a.i kg-1	W7 / 1 1	-	31.64	47.46	75.94	93.34		
	waterlogged	+	42.71	61.7	96.5	104.41		
		-	49.05	26.9	80.69	31.64		
Soil + Chloropyriphos at	60% of MHC	+	41.14	56.95	60.12	28.48		
0.5 mg a.i kg-1	XX7 / 1 1	-	34.8	64.86	63.29	72.76		
	Waterlogged	+	47.46	82.43	30 30 69.54 83.9 31.64 55.37 99.67 102.82 75.94 96.5 80.69 60.12 63.29 72.77 66.45 90.18 68.03 104.41 56.95 66.45 50.62 69.61 0.0176 0.1437 0.0246 0.0246 0.0246 0.0378 0.0378 0.0378 0.0654 0.0924	87.01		
		-	42.71	50.63	66.45	53.79		
Soil + Endosulfan at 1.0	60% of MHC	+	37.97	39.55	90.18	72.78		
mg a.i kg-1	XX7 / 1 1	-	72.77	87.01	30 30 69.54 83.9 31.64 55.37 99.67 102.82 75.94 96.5 80.69 60.12 63.29 72.77 66.45 90.18 68.03 104.41 56.95 66.45 90.18 68.03 104.41 56.95 66.45 90.18 0.0176 0.01437 0.0246 0.0246 0.0246 0.0246 0.0378 0.0378 0.0378 0.0654 0.0534	87.01		
	Waterlogged	+	80.68	91.76	30 30 69.54 83.9 31.64 55.37 99.67 102.82 75.94 96.5 80.69 60.12 63.29 72.77 66.45 90.18 68.03 104.41 56.95 66.45 50.62 69.61 0.0176 0.1437 0.0246 0.0246 0.0246 0.0246 0.0378 0.0378 0.0378 0.0654 0.0534	107.58		
		-	29.74	25.31	56.95	37.97		
Soil + Chloropyriphos at	60% of MHC	+	28.48	53.79	66.45	39.55		
1.0 mg a.i kg-1		-	52.21	36.39	50.62	69.62		
	Waterlogged	+	58.53	68.03	30 69.54 83.9 31.64 55.37 99.67 102.82 75.94 96.5 80.69 60.12 63.29 72.77 66.45 90.18 68.03 104.41 56.95 66.45 50.62 69.61 0.0176 0.1437 0.0246 0.0246 0.0246 0.0246 0.0378 0.0378 0.0378 0.0654 0.0534	75.94		
		Soils (S)	0.8854	0.0176	30 12 69.54 07 83.9 .8 31.64 01 55.37 54 99.67 19 102.82 46 75.94 .7 96.5 .9 80.69 95 60.12 86 63.29 43 72.77 63 66.45 55 90.18 01 68.03 76 104.41 31 56.95 79 66.45 39 50.62 03 69.61 176 0.0176 437 0.1437 437 0.1437 437 0.1437 436 0.0246 202 0.0202 349 0.0349 185 0.0463 152 0.0378 152 0.0378 152 0.0378 152 0.0378 <td>0.0176</td>	0.0176		
		Nitrogen(N)	0.7229	0.1437	0.1437	0.1437		
		Moisture(M)	0.7229	0.1437	0.1437	0.1437		
	Endosulfan	SXN	1.2522	0.0246	30 30 69.54 5 83.9 31.64 7 55.37 1 99.67 3 102.82 4 75.94 9 96.5 1 80.69 3 60.12 2 63.29 7 72.77 8 66.45 5 90.18 7 66.45 3 66.45 3 66.45 3 66.45 3 66.45 3 66.45 3 66.45 3 66.45 3 66.45 3 66.45 3 66.45 3 66.45 3 0.0176 0 0.1437 0 0.0246 0 0.0246 0 0.0378 0 0.0378 0 0.065	0.0246		
		SXM	1.2522	0.0246	0.0246	0.0246		
		NXM	1.022	0.0202	0.0202	0.0202		
		SXNXM	1.771	0.0349	30.12 00.13 00.13 73.07 83.9 52.2 34.8 31.64 72.7 87.01 55.37 109.1 58.54 99.67 37.3 71.19 102.82 41.1 47.46 75.94 93.3 61.7 96.5 104.4 26.9 80.69 31.6 56.95 60.12 28.4 54.86 63.29 72.7 82.43 72.77 87.00 50.63 66.45 53.7 87.01 68.03 87.00 50.63 66.45 39.5 90.18 72.7 87.01 68.03 87.00 01.76 104.41 107.5 25.31 56.95 37.9 53.79 66.45 39.5 36.39 50.62 69.6 58.03 69.61 75.9 $.0176$ 0.0176 0.017 $.01437$ 0.1437 0.143 $.0246$ 0.0246 0.024 $.0202$ 0.0202 0.0202 $.0349$ 0.0349 0.034 $.0152$ 0.0378 0.015 $.0264$ 0.0654 0.025 $.0214$ 0.0534 0.021 $.0372$ 0.0924 0.062	0.0349		
CD (P=0.05)		Soils (S)	0.0185	0.0185		0.0182		
		Nitrogen (N)	0.0152	0.0152	0.0378	0.0150		
		Moisture (M)	0.0152	0.0152	0.0378	0.0150		
	Chloropyrophos	SXN	0.0264	0.0264	8 31.64 72 01 55.37 10 54 99.67 33 19 102.82 44 46 75.94 92 7 96.5 100 9 80.69 3 95 60.12 24 43 72.77 8° 63 66.45 55 90.18 72 63 66.45 57 61 68.03 8° 70 66.45 39 70 66.45 39 70 66.45 39 70 66.45 39 70 66.45 39 70 66.45 39 39 50.62 69 37 0.1437 0.0 37 0.1437 0.0 37 0.1437 0.0 46 0.02	0.0258		
		SXM	0.0264	0.0264	0.0654	0.0258		
		NXM	0.0214	0.0214	0.0534	0.0211		
		SXNXM	0.0372	0.0372	69.54 83.9 31.64 55.37 99.67 102.82 75.94 96.5 80.69 60.12 63.29 72.77 66.45 90.18 68.03 104.41 56.95 66.45 50.62 69.61 0.0176 0.1437 0.0246 0.0246 0.0246 0.0246 0.0378 0.0378 0.0654 0.0534	0.0628		

Table 3. Effect of pesticides and moisture regimes on changes in the amount (mg kg⁻¹) of soluble NO₃⁻ in soil treated with or without inorganic N



Treatments	Maistura ragimas	N foutilization	Incubation period (Days)			
Treatments	woisture regimes	N-Iertilization	0	15	30	60
	(00/ -£MUC	-	97.86	109.16	110.67	85.42
Soil	00% 01 MHC	+	178.76	155.33	159.84	101.24
5011	337.4 1 1	-	96.48	79.09	72.77	113.9
	wateriogged	+	190.91	169.37	30 30 110.67 159.84 72.77 124.99 211.99 251.53 251.86 283.17 180.36 207.25 193.01 234.13 186.64 259.45 168.06 273.68 166.11 226.24 175.6 211.99 0.0176 0.07905 0.0246 0.0246 0.0246 0.0246 0.42255 0.73185 0.73185 0.59755 1.03505	161.36
	(00/ -£MIIC)	-	82.26	109.16	211.99	76.92
Soil + Endogulfan at 0,5 mg a i kg-l	0076 01 WITE	+	177.18	177.16	251.53	82.44
Soli + Endosunan at 0.5 mg a.i kg	Watarlaggad	oisture regimes N-fertilization 0 15 % of MHC - 97.86 109.16 1 + 178.76 155.33 1 aterlogged - 96.48 79.09 7 aterlogged + 190.91 169.37 1 % of MHC - 82.26 109.16 2 + 177.18 177.16 2 aterlogged - 96.17 101.24 2 + 191.44 145.21 2 % of MHC - 107.59 104.42 1 % of MHC - 107.06 124.98 1 + 178.77 137.3 2 aterlogged - 107.06 124.98 1 + 192.55 148.87 2 2 % of MHC - 192.55 148.87 2 % of MHC - 197.71 172.44 2 % of MHC - 125.05<	96.17	101.24	251.86	189.9
	waterioggeu		283.17	221.47		
	60% of MHC	-	107.59	104.42	180.36	82.26
Soil + Chloropyriphos at 0.5 mg a.i	0076 01 WITE	+	178.77	137.3	207.25	87.01
kg ⁻¹	Watarlaggad		107.06	124.98	193.01	156.59
	waterioggeu	- 97.86 1 + 178.76 1 - 96.48 7 + 190.91 1 - 82.26 1 + 177.18 1 - 96.17 1 + 191.44 1 - 96.17 1 + 191.44 1 - 96.17 1 + 191.44 1 - 107.59 1 + 192.55 1 - 107.06 1 + 192.55 1 - 93.33 1 + 187.65 1 - 128.19 7 + 197.71 1 - 99.67 9 + 170.86 0 - 125.05 9 + 206.94 1 Soils(S) 0.4515 0 <td< td=""><td>148.87</td><td>234.13</td><td>183.51</td></td<>	148.87	234.13	183.51	
	60% of MHC	-	93.33	143.97	186.64	94.92
Soil + Endogulfan at 1.0 mg a i kg-l	0076 01 WITE	+	187.65	186.16	259.45	137.25
Son + Endosunan at 1.0 mg a.i kg	Watarlaggad	-	128.19	131.3	168.06	137.63
	waterlogged	+	197.71	172.44	273.68	186.86
Soil + Endosulfan at 1.0 mg a.i kg ⁻¹ Soil + Chloropyriphos at 1.0 mg a.i kg ⁻¹	60% of MHC	-	99.67	91.75	166.11	72.8
		+	170.86	175.6	226.24	112.32
	Weterlessel	-	125.05	93.34	175.6	156.63
	waterioggeu	+	0 15 97.86 109.16 178.76 155.33 96.48 79.09 190.91 169.37 82.26 109.16 177.18 177.16 96.17 101.24 191.44 145.21 107.59 104.42 178.77 137.3 107.06 124.98 192.55 148.87 93.33 143.97 187.65 186.16 128.19 131.3 197.71 172.44 99.67 91.75 170.86 175.6 125.05 93.34 206.94 197.75 0.4515 0.02755 0.36865 0.08725 0.36865 0.08725 0.36865 0.08725 0.36865 0.08725 0.036865 0.02935 0.0185 0.02935 0.0185 0.02935 0.0185 0.02935 0.0185	211.99	164.47	
		Soils(S)	0.4515	0.02755	0.0176	0.0176
		Nitrogen(N)	0.36865	0.08725	0.07905	0.07905
		Moisture(M)	0.36865	0.08725	0.07905	0.07905
	Endosulfan	SXN	0.6384	0.039	0.0246	0.0246
		SXM	0.6384	0.039	0.0246	0.0246
		NXM	0.5211	0.0318	0.0202	0.0202
		SXNXM	0.90295	0.05515	0.0349	0.0349
CD (P=0.05)		Soils(S)	0.0185	0.02935	0.5176	0.39195
		Nitrogen(N)	0.0152	0.024	0.42255	0.3201
	Chloropyrophos	Moisture(M)	0.0152	0.024	0.42255	0.3201
		SXN	0.0264	0.04165	0.73185	0.55425
		SXM	0.0264	0.04165	0.73185	0.55425
		NXM	0.0214	0.03385	0.59755	0.45265
		SXNXM	0.0214	0.0598	1.03505	0.7971
		521172111	0.0372	0.0500	1.05505	0.7971

Table 4. Effect of pesticides and moisture regimes on changes in the amount (mg kg⁻¹) of available N in soil treated with or without inorganic N

Effect of moisture regimes and pesticides of different biodegradability on transformation



Table 5. Effect of pesticides and moisture regimes on changes in the amount (mg kg⁻¹) of hydrolysable organic NH4⁺ -N insoil treated with or without inorganic N



Tuestry on te	Maisture regimes	N-fertilization - - - + - - - + - - - + - - - + - - - + - - - + - - - + - - - + - - - + - - - + - - - + - - - + - - - + - - - + - - - + - - - + - - - + - - - + - - - <t< th=""><th colspan="4">Incubation period (Days)</th></t<>	Incubation period (Days)			
Treatments	Moisture regimes		0	15	30	60
	600/ of MUC	-	27.36	25.00	27.56	33.20
Coll	00% 01 WIHC	+	38.40	28.60	40.62	36.48
Son	XX7 (1 1	-	27.36	24.92	26.86	29.68
	wateriogged	+	38.40	26.74	27.40	32.12
	600/ of MUC	-	27.36	34.36	41.56	32.48
Soil - Endegylfen at 0.5 mg a i ko-l	00% 01 WIHC	+	31.04	36.48	29.86	26.60
Son + Endosunan at 0.5 mg a.i kg	Waterlaggad	Inter regimes N-fertilization 0 15 30 MHC - 27.36 25.00 27.3 $+$ 38.40 28.60 40.0 gged - 27.36 24.92 26.3 $+$ 38.40 26.74 27.3 MHC - 27.36 34.36 41.3 $+$ 31.04 36.48 29.3 gged - 27.46 27.04 26.3 $+$ 28.32 30.48 31.1 $+$ 28.32 30.48 31.1 $-$ 29.20 28.96 25.3 $+$ 38.41 39.34 26.5 $+$ 30.32 37.30 30.3 $+$ 29.40 33.70 26.4 MHC - 31.04 32.68 36.0 $+$ 23.24 36.40 26.3 36.3 $gged$ - 27.04 26.27 27.3 $+$	26.30	30.46		
	wateriogged		31.26	36.28		
	600/ of MUC	-	29.20	28.96	25.80	29.46
Soil + Chloropyriphos at 0.5 mg a.i	00% 01 WIHC	+	38.41	39.34	26.20	38.70
kg ⁻¹	Watarlana	-	30.32	37.30	30.86	29.36
	wateriogged	regimes N-fertilization 0 15 30 C - 27.36 25.00 27.56 + 38.40 28.60 40.62 d - 27.36 24.92 26.86 + 38.40 26.74 27.40 C - 27.36 34.36 41.56 + 31.04 36.48 29.86 + 31.04 36.48 29.86 - 27.46 27.04 26.30 d - 27.46 27.04 26.30 d - 29.20 28.96 25.80 F 30.32 37.30 30.86 + 29.40 33.70 26.64 C - 31.04 32.68 36.06 + 26.32 27.36 31.28 d - 26.86 34.28 29.86 + 23.24 36.40 26.82 (C - 34.	26.64	26.82		
	(00/ -£MUC	-	31.04	32.68	36.06	29.70
Soil - Endowalfor of 1.0 mars i logi	60% OI MHC	+	26.32	27.36	31.28	25.62
Soll + Endosulian at 1.0 mg a.1 kg	Watarlana	-	26.86	34.28	29.86	29.48
	Waterlogged	+	23.24	36.40	26.82	30.82
Soil + Chloropyriphos at 1.0 mg a.i	$ \begin{array}{c} \mbod line regime in transition (0) \\ \mbod line regime in transition (0) \\ \mbod line regime in the regime in transition (0) \\ \mbod line regime in the regime in$	-	34.04	34.68	39.66	36.30
		+	39.12	26.86	36.22	34.70
kg ⁻¹		27.04	26.27	27.58	34.28	
	wateriogged	+	0 15 30 27.36 25.00 27.56 38.40 28.60 40.62 27.36 24.92 26.86 38.40 26.74 27.40 27.36 34.36 41.56 31.04 36.48 29.86 27.46 27.04 26.30 28.32 30.48 31.26 29.20 28.96 25.80 38.41 39.34 26.20 30.32 37.30 30.86 29.40 33.70 26.64 31.04 32.68 36.06 26.32 27.36 31.28 26.86 34.28 29.86 23.24 36.40 26.82 34.04 34.68 39.66 39.12 26.86 36.22 27.04 26.27 27.58 19.28 24.48 28.46 0.0152 0.3411 0.0152 0.5991 3.796 1.9956 0.59	36.26		
		Soils(S)	0.0185	0.4179	0.0185	1.2572
Soil + Endosulfan at 0.5 mg a.i kg ⁻¹ Soil + Chloropyriphos at 0.5 mg a.i kg ⁻¹ Soil + Endosulfan at 1.0 mg a.i kg ⁻¹ Soil + Chloropyriphos at 1.0 mg a.i kg ⁻¹ CD (P=0.05)		Nitrogen(N)	0.0152	0.3411	0.0152	1.0267
		Moisture(M)	0.0152	0.3411	0.0152	1.0267
	Endosulfan	SXN	0.5991	3.796	1.9956	1.7813
		SXM	0.5991	3.796	1.9956	1.7813
		NXM	0.4892	3.0995	1.6294	1.4546
		SXNXM	0.8472	5.3681	2.822	2.5194
CD (P=0.05)		Soils(S)	0.4238	2.6842	1.4112	1.2596
		Nitrogen(N)	0.3460	2.1915	1.1522	1.0285
		Moisture(M)	0.3460	2.1915	1.1522	1.0285
	Chloropyrophos	SXN	0.0264	0.5909	0.0264	1.778
		SXM	0.0264	0 5909	0.0264	1 778
		NXM	0.0214	0.4824	0.0214	1 4519
		SXNXM	0.0372	0.8358	0.0372	2 5147

 Table 6. Effect of pesticides and moisture regimes on changes in the amount (mg kg-1) of hexosamine-N in soil treated with or without inorganic N

Effect of moisture regimes and pesticides of different biodegradability on transformation

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Tweatments	Maistura ragimas	N fortilization	Incubation period (Days)			
Treatments	Moisture regimes	N-Iertifization	0	15	30	60
	60% of MHC	-	582.40	360.22	606.09	266.00
Soil	0070 01 MIRC	+	291.20	336.98	697.20	372.40
3011	Watarlaggad	-	313.74	648.62	255.64	441.56
	waterioggeu	+	429.94	449.78	406.70	464.80
	60% of MHC	-	393.12	139.44	518.70	305.90
Soil + Endosulfan at 0,5 mg a i kg 1		+	305.76	336.98	499.66	305.90
Soli + Endosultan at 0.5 mg a.i kg-1	Waterlogged	-	313.74	357.11	302.12	325.36
	wateriogged	+	306.22	523.22	325.36	406.70
	60% of MHC	-	276.64	252.49	430.08	252.70
Soil + Chloropyriphos at 0.5 mg a.i	0070 01 101110	+	218.40	267.26	571.90	212.80
kg-1	Watarlaggad	N-fertilization 0 15 f MHC - 582.40 360.22 ogged + 291.20 336.98 ogged + 291.20 336.98 ogged + 429.94 449.78 f MHC + 393.12 139.44 f MHC + 305.76 336.98 ogged - 313.74 357.11 ogged - 313.74 357.11 ogged + 306.22 523.22 f MHC + 306.22 523.22 f MHC + 218.40 267.26 ogged - 276.64 252.49 f MHC + 209.16 1 f MHC - 232.96 209.16 f MHC + 305.76 300.58 ogged - 327.82 411.32 ogged - 495.04 345.61 f MHC + 324.96 363.72 </td <td>418.32</td> <td>464.80</td>	418.32	464.80		
	waterioggeu	+	01530582.40360.22606.09291.20336.98697.20313.74648.62255.64429.94449.78406.70393.12139.44518.70305.76336.98499.66313.74357.11302.12306.22523.22325.36276.64252.49430.08218.40267.26571.90429.94427.72418.32502.81561.46450.72232.96209.16649.74305.76300.58383.46327.82411.32232.40383.46480.26441.56495.04345.61558.32324.96363.72383.46499.66411.32325.36604.24645.47476.420.01760.01760.01760.01440.01440.01440.02460.02460.02460.02460.02460.02460.02020.02020.02020.03490.03490.03490.00880.76570.01850.01520.62520.01520.02641.08270.02640.02140.88420.02140.03721.53140.0372	429.92		
	60% of MUC	-	232.96	209.16	649.74	252.70
Soil + Endowlfon at 1.0 mg a i ltg 1	00% 01 WINC	+	305.76	300.58	383.46	292.60
Soll + Endosultan at 1.0 mg a.1 kg-1	Watarlagaad	-	327.82	411.32	232.40	581.00
	waterlogged	+	383.46	480.26	441.56	697.20
Soil + Chloropyriphos at 1.0 mg a.i	60% of MHC	-	495.04	345.61	558.32	345.80
		+	324.96	363.72	383.46	372.40
kg-1	Waterlagged	-	499.66	411.32	325.36	360.22
	wateriogged	+	604.24	645.47	Incubation period (Days)1530360.22606.09336.98697.20648.62255.64449.78406.70139.44518.70336.98499.66357.11302.12523.22325.36252.49430.08267.26571.90427.72418.32561.46450.72209.16649.74300.58383.46411.32232.40480.26441.56345.61558.32363.72383.46411.32325.36645.47476.420.01760.01760.01440.01440.02460.02460.02460.02460.02020.03490.76570.01850.62520.01521.08270.02640.88420.02141.53140.0372	453.18
		Soils(S)	0.0176	0.0176	0.0176	0.0176
		Nitrogen(N)	0.0144	0.0144	0.0144	0.0144
		Moisture(M)	0.0144	0.0144	0.0144	0.0144
	Endosulfan	SXN	0.0246	0.0246	0.0246	0.0246
		SXM	0.0246	0.0246	0.0246	0.0246
		NXM	0.0202	0.0202	0.0202	0.0202
		SXNXM	0.0349	0.0349	0.0349	0.0349
CD (P=0.05)		Soils(S)	0.0088	0.7657	0.0185	42.3286
		Nitrogen(N)	0.0152	0.6252	0.0152	34,5610
		Moisture(M)	0.0152	0.6252	0.0152	34,5610
	Chloropyrophos	SXN	0.0264	1.0827	0.0264	59.8614
	FJ-ophioo	SXM	0.0264	1 0827	0.0264	59 8614
		NXM	0.0201	0.8842	0.0201	48 8768
		SYNVM	0.0214	1 5214	0.0214	81 6569
		SAINAIN	0.0372	1.5514	0.0372	04.0300

Table 7. Effect of pesticides and moisture regimes on changes in the amount (mg kg⁻¹) of Amino acid-N in soil treated with or without inorganic N

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S1 = Control soil, $S2 = S1 + Endosulfan at 0.5 mg a.i kg^{-1}$, $S3 = Soil + Chloropyriphos at 0.5 mg a.i kg^{-1}$, $S4 = Soil + Endosulfan at 1.0 mg a.i kg^{-1} and S5 = Soil + Chloropyriphos at 1.0 mg a.i kg^{-1}$



Figure 1. Effect of pesticides on change in different forms of N at 60% MHC of soil treated with inorganic N

S1 = Control soil, $S2 = S1 + Endosulfan at 0.5 mg a.i kg^{-1}$, $S3 = Soil + Chloropyriphos at 0.5 mg a.i kg^{-1}$, $S4 = Soil + Endosulfan at 1.0 mg a.i kg^{-1} and S5 = Soil + Chloropyriphos at 1.0 mg a.i kg^{-1}$

Figure 2. Effect of pesticides on change in different forms of N under waterlogged soil treated without inorganic N

Effect of moisture regimes and pesticides of different biodegradability on transformation



S1 = Control soil, $S2 = S1 + Endosulfan at 0.5 mg a.i kg^{-1}$, $S3 = Soil + Chloropyriphos at 0.5 mg a.i kg^{-1}$, $S4 = Soil + Endosulfan at 1.0 mg a.i kg^{-1} and S5 = Soil + Chloropyriphos at 1.0 mg a.i kg^{-1}$



Figure 3. Effect of pesticides on change in different forms of N at 60% MHC of soil treated with inorganic N

S1 = Control soil, $S2 = S1 + Endosulfan at 0.5 mg a.i kg^{-1}$, $S3 = Soil + Chloropyriphos at 0.5 mg a.i kg^{-1}$, $S4 = Soil + Endosulfan at 1.0 mg a.i kg^{-1} and S5 = Soil + Chloropyriphos at 1.0 mg a.i kg^{-1}$

Figure 4. Effect of pesticides on change in different forms of N under waterlogged soil treated with inorganic N



exchangeable NH₄⁺ is recorded in waterlogged system over the soil maintained under 60% of the moisture holding capacity (MHC) at all stages of incubation. This trend of result is observed both in presence and absence of inorganic N and pesticides (endosulfan and chloropyriphos) addition. Higher amount of exchangeable NH⁺ produced in waterlogged soil due to faster rate of mineralization of organic N over unflooded situations but very little is transformed to NO_{2}^{-} form perhaps due to lower N requirement of the microbial population under anaerobic environment and to their lower synthetic efficiency (Saha and Mukhopadhyay 1983b). Again, irrespective of N-additions, comparatively lower amount of exchangeable NH⁺ is recorded in waterlogged soil treated with higher dose of endosulfan, whereas, almost similar amount of exchangeable NH⁺₄ is recorded in waterlogged soil treated with both the higher and lower doses of chloropyriphos throughout the period of investigation. However, soil kept at 60% MHC showed an exactly opposite trend of results both in higher doses of endosulfan and chloropyriphos. Thus it is clear from the results that addition of pesticides of different biodegradability hinders the ammonification process particularly under waterlogged situation in presence of inorganic N (Okamoto et al. 1999).

Irrespective of pesticides (endosulfan and chloropyriphos) addition, moisture regimes and period of investigation, comparatively, higher amount of soluble NO3⁻ is accumulated in N-treated over the untreated system (Table 3). In general, irrespective of pesticides and inorganic N, higher amount of soluble NO₃⁻ is recorded in soil kept at lower moisture regime. However, at the last stage of incubation, comparatively higher amount of soluble NO_3^{-} -N is accumulated in waterlogged system than the soil maintained at 60% MHC (Table 3). The higher dose of endosulfan favours nitrification even under waterlogged condition. This finding is due to less scope of loss of N through leaching as well as denitrification. The nitrification process is found to be accelerated at last stage of incubation (Saison et al. 2009).

Comparatively higher amount of available N is accumulated in N treated over the untreated system (Table 4). Again, irrespective of chloropyriphos treatment and N fertilization, in general, comparatively higher amount of available N was recorded in waterlogged over that of the soil maintained at 60% of MHC. The explanation furnished earlier is equally appreciable here as well. Soils maintained at 60% of MHC and fertilised with inorganic N showed a decrease in available N over the experimentation period is due to conversion of exchangeable NH₄⁺ to other forms of N and loss through volatilization (Broadbent and Tusneem 1971) and or immobilization (Saharawat 1982). Furthermore irrespective of moisture regimes, available N increased up to 30th day in both the doses of Chlorpyriphos treated systems. The result is at par with earlier works of Das (1997). However, after 30 days, a decreasing trend was observed up to the last stage of incubation. This is because of immobilization of exchangeable NH_4^+ in soil (Pal *et al.* 1987).

Irrespective of moisture regimes and pesticides addition, in general, comparatively higher amount of total hydrolysable NH⁺₄ is accumulated in N-treated over the untreated system throughout the period of investigation (Table 5). Data also reveal that in absence of endosulfan but presence of chloropyriphos and inorganic N, in general, comparatively lower amount of hydrolysable NH⁺₄ -N is recorded in waterlogged over the soil maintained at 60% of MHC in particularly at the later stages of incubation. At lower dose of both the pesticides, comparatively lower amount of hydrolysable organic NH⁺₄ -N was accumulated in waterlogged system over the soil kept of 60% MHC, whereas, at higher dose no definite trend of results was obtained. Conversion of hydrolysable NH₄⁺-N to other organic forms and vice-versa was suggested (Devi 2009; Saha 1987). Thus it is clear that introduction of pesticides in the system slowed down the N-mineralization process (Ollivier et al. 2011; Ukru 2005) and maintenance of lower level of moisture is congenial for accumulation of higher order of hydrolysable NH⁺₄ in soil through inter-conversion of other forms of organic N.

Data in Table 6 revealed that both the doses of endosulfan has no drastic effect in accumulation of hexosamine Nin soil treated with or without inorganic N. However, at the lower dose of Chloropyriphos treated, comparatively lower amount of hexosamine – N was recorded at the end of incubation period in the soils treated with inorganic N. The decrease was more pronounced in waterlogged situation than the soils maintained under 60% MHC. Soils treated with higher dose of chloropyriphos showed an increasing trend of accumulation of hexosamine - N throughout the period of incubation. The recorded higher amount of hexosamine - N in untreated soils at the end of incubation period is due to immobilization of inorganic forms of N in soils. This trend of results is observed for the soils maintained under both the moisture levels.

Perusal of the results in Table 7 revealed that irrespective of moisture regimes and pesticides addition, comparatively higher amount of amino acid-N is accumulated in N-treated over the untreated system particularly at the later stage of investigation. Again, irrespective of N-fertilization, at higher dose of pesticides, a favourable environment was created to register a comparatively higher amount of amino acid-N in waterlogged over the soil maintained at 60% of the MHC. Similar findings were also reported earlier by Mukhopadhyay et al. (1985). The increase in amino acid-N with concomitant decrease in hydrolysable organic NH₄⁺ -N under waterlogged situation leads to conclude that different fractions of organic N are inter-convertible within themselves depending upon the microenvironment of the rhizosphere soil (Saha 1999).

To get a clear picture of the effect of pesticides on changes in different forms of N in soil maintained under two different moisture regimes in presence and absence of added inorganic N, the mean value of the data at different stages are graphically presented in Figure 1 to 4. Irrespective of pesticidal treatments, in general, high amount of available N is accumulated in waterlogged than the soil maintained at 60% of NHC (Figure 1 and 2). N addition leads to accumulation of higher amount of available N in soil (Figure 3 and 4). Addition of pesticides has little effect on hexosamine N in soil (Figure 1 to 4). However, pesticide treatment influenced the accumulation of hydrolysable NH₄⁺ and amino acid N in soils. Addition of pesticides either endosulfan or chloropyriphos at lower dose, in general, decreased the hydrolysable NH₄⁺ but on the other hand, increased amino acid N in soil. Therefore, it is clear that pesticides have an impact on mineralization and immobilization of organic and inorganic N in soil.

Conclusion

Addition of pesticides of different biodegradability hinders the ammonifying process but on the other hand, encourages nitrification. Higher dose of endosulfan favours nitrification even under waterlogged situation. Addition of Endosulfan and Chloropyriphos increased the accumulation of available N in soil particularly under waterlogged situation. Different forms of organic N are interconvertible within themselves.

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