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STUDIES ON AVAILABILITY OF FIXED NH_4^+ TO NITRIFYING ORGANISMS

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SUMMARY

Nitrification of fixed NH_4^+ in 18 soils representing different agro-climatic regions of West Bengal reveals that 5.5 to 47.9% of fixed NH_4^+ is nitrified over a 45-day incubation period. Although, nitrification of fixed NH_4^+ increases with the increase in the incubation period, most of it is nitrified between the 15th and 30th day. When the NH_4^+-fixing power of the soil increases the availability of fixed NH_4^+ to nitrifying bacteria decreases.

INTRODUCTION

Many research reports [2 3 4 7 10] revealed that a small portion of the fixed NH_4^+ is nitrified by nitrifying organisms. With only 2 soils, Bower [7] observed that only 13 to 28 per cent of the fixed NH_4^+ was nitrified during the 14 day incubation; extending the incubation period did not yield any further release of fixed NH_4^+. Allison *et al.*[2 3 4 5] reported that the availability of fixed NH_4^+ to nitrifiers did not exceed 10 per cent and such availability depends on the mineralogical composition of soil. In one geological specimen of vermiculite, almost all of the fixed NH_4^+ was nitrified, whereas in another specimen (a South African Sample) only 11 to 16 per cent was available to nitrifiers. Specific objective of the present study is to find out from an incubation experiment, the extent of availability of fixed NH_4 to nitrifying organisms in soils of West Bengal representing different agro-climatic zones.

MATERIALS AND METHODS

The experiment was carried out with 18 soils of West Bengal representing different agro-climatic regions. The relevant physico-chemical properties of the soils are presented in Table 1. The soil samples were prepared according to the method of Allison *et al* [2]. The soil samples were passed through an 80-mesh sieve and treated with a saturated solution of $(NH_4)_2SO_4$, and dried on a water bath (60°C). The process was repeated thrice. Samples were then extracted in 100-g lots in glass extraction tubes with 1*N* KCl, added in small portions. The extraction was continued without suction, until there was no longer a test for ammonia with Nessler's reagent. Then to each 100 g portion was added 100 ml of $CaCl_2$ to remove most of the exchangeable K^+ and fix the humate as calcium humate. The soil residue was then leached with 200 ml of a 0.1*N* $CaCl_2$–$MgCl_2$ (9:1) mixture, followed by distilled water until there was only a slight test for chloride in the filtrate. The final leaching was carried out with 200 ml of salt solution consisting of 2 g KH_2PO_4, 0.2 g $MgSO_4$, trace of $FeCl_3$ and Arnon's A-5 solution of minor elements per litre. After air drying, the samples were taken for nitrification studies. Before this, the fixed NH_4^+ present in the samples were determined by the method of Silva and Bremner [11].

TABLE 1

Relevant physical and chemical characteristics of soils

Sample No	Clay %	Dominant clay mineral	Organic C %	pH	CEC me/100 g	Total N %	Native fixed NH_4^+ me/100 g	NH_4^+ fixing capacity me/100 g
1	7	I*, V	0.88	6.6	4.7	0.06	1.16	1.98
2	10	K*, I	0.58	5.9	7.1	0.05	0.77	3.42
3	22	K*, I	0.78	7.0	10.2	0.05	0.77	1.81
4	30	I*, K	0.56	5.4	11.6	0.05	0.73	1.66
5	30	I*, K	0.64	6.0	13.5	0.06	0.78	1.95
6	57	K*, I	0.78	6.7	21.2	0.06	0.91	2.50
7	16	I*, K	0.33	5.1	10.7	0.04	0.66	1.95
8	17	I*, V	0.71	5.6	17.5	0.05	1.58	13.62
9	11	I*, K	0.43	7.1	13.8	0.05	0.70	1.70
10	23	I*, K	0.76	7.4	17.9	0.08	1.86	3.80
11	31	I*, V	0.65	8.3	17.2	0.08	1.63	10.33
12	46	I*, K	0.58	6.8	20.5	0.06	1.67	4.42
13	57	I*	0.66	7.4	21.3	0.07	2.28	8.68
14	48	I*, K	0.79	7.0	22.5	0.07	1.78	5.10
15	53	I*, K	0.59	6.9	16.5	0.05	1.93	3.29
16	72	I*, K	0.78	7.6	30.0	0.06	2.20	7.46
17	20	I*, K	0.74	7.5	11.3	0.06	1.27	7.14
18	43	I*, K	0.81	8.3	10.4	0.07	1.96	2.77

*: Dominant; I: Illite; K: Kaolinite; V: Vermiculite.

The incubation for nitrification study was conducted at 28°C using 50 g of soil in 250-ml Erlemeyer flask, covered with an inverted beaker. The soil containing the fixed NH_4^+ was inoculated with 2 g of a soil known to have an active nitrifying flora. The optimum moisture was maintained at 50 per cent of field capacity by the addition of requisite amount of distilled water on every third day. The samples were analysed for nitrate content after 15, 30, and 45 days of incubation. The extracts were collected by adding distilled water (150 ml) and 1 g CaO to each container, shaking for 30 minutes and filtering. Aliquots were taken for nitrate analysis and determined by the phenol disulfonic acid method [8].

RESULTS AND DISCUSSION

The results of nitrification of the fixed NH_4^+ in soils of varying fixing capacities are shown in Table 2. It is observed that over a period of 45 days of incubation, the percentage of fixed NH_4^+ nitrified increases with the increase in the period of incubation and the

TABLE 2

Nitrification of fixed NH_4^+ in soils

Sample No	Fixed NH_4^+ present in the samples before incubation me/100 g	Incubation period in days					
		15		30		45	
		A*	B*	A	B	A	B
1	1.61	0.16	9.9	0.37	23.0	0.44	27.3
2	2.81	0.21	7.5	0.34	12.1	0.35	12.5
3	1.22	0.35	26.7	0.50	41.0	0.57	46.7
4	1.66	0.26	15.7	0.52	31.3	0.64	38.6
5	1.90	0.26	13.7	0.39	20.5	0.45	23.7
6	2.31	0.26	11.2	0.70	21.6	0.60	26.0
7	1.95	0.16	8.2	0.42	21.8	0.48	25.0
8	7.10	0.17	2.5	0.35	10.7	0.95	13.2
9	1.67	0.35	20.9	0.57	34.1	0.60	35.9
10	3.10	0.43	13.9	0.57	18.4	0.70	22.9
11	5.40	0.17	3.2	0.35	6.5	0.85	15.7
12	4.29	0.10	2.3	0.25	5.8	0.32	7.4
13	6.30	0.14	2.2	0.34	5.3	0.38	6.3
14	3.29	0.17	3.6	0.26	7.9	0.28	8.5
15	2.51	0.30	12.0	0.50	19.9	0.57	22.7
16	5.32	0.12	2.3	0.26	4.9	0.32	6.0
17	5.81	0.18	3.1	0.30	5.2	0.32	5.5
18	2.62	0.14	5.3	0.21	8.0	0.25	9.5

* A = NO_3 nitrogen me/100 g. B = % of fixed NH_4^+ nitrified.

maximum nitrification of fixed NH_4^+ varies from 5.5 to 47.9 per cent. Axley and Legg [6] observed a decrease in the percentage availability of added NH_4^+ to nitrifying organisms with increasing NH_4^+ fixing capacity of the soil. The soils used in the present investigation vary widely in their ammonium-fixing capacities. Therefore, in order to relate NH_4^+-fixing power of the soil to nitrification of fixed NH_4^+, the soils are classified into three arbitrary classes based in their fixing capacities, namely, low, upto 2 me/100 g; medium, 2 to 3.5 me/100 g and high above 3.5 me/100 g. The mean of the percentages of fixed NH_4^+ nitrified in soils of these three classes are found to be 35.0, 16.9 and 9.0 respectively. A highly significant negative correlation ($r = -0.7437$) exists between the NH_4^+-fixing capacity of the soil and the percentage of fixed NH_4^+ nitrified.

The low availability of fixed NH_4^+ to nitrifiers in soils of high fixing capacity and vice-versa, thus indicate that fixed NH_4^+ in the lattice sites is not accessible to nitrifying organisms. A similar explanation has been put forwarded by Allison *et al.*[4].

A closer examination of the results further reveals that most of the nitrification of fixed NH_4^+ occur between 15th and 30th day of the 45-day incubation period. Lutz [9] also observed a surge of NO_3^- production between the 21st and 28th day, amounting to 5 to 10 times that occuring during other incubation periods. The slowing down of nitrification after 30th day may be due to gradually increasing non-availability of fixed NH_4^+ and also to the increasing concentration of nitrate in the medium, which is known to suppress nitrification [1]. An average of 21.0 per cent of fixed NH_4^+ is nitrified during the 45 days of incubation. This is also in accordance with the results reported by Lutz [9], who observed 20.4 per cent for some selected soils of South Eastern United States.

In soils of high NH_4^+-fixing capacities (above 3.5 me/100 g) dominated by illite and vermiculite, 5.5 to 15.7 per cent of fixed NH_4^+ was found to be nitrified with a mean value of 9.0 per cent.

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