Studies on the Soils of Kuttanad - Part II

MICROBIOLOGICAL NITROGEN TRANSFORMATIONS IN ACID PEAT SOILS OF KUTTANAD *

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THE PROCESS OF NITROGEN TRANSOFRMATION in acid soils is not fully understood. Leibig showed that presence of certain toxic substances such as high concentration of salts and extreme acidity inhibit bacterial activity. Olsen (1928) proved that ammonifiers can function in 3.7-9 pH range. Meek and Lipman (1922) found that the pH tolerance of the nitrifying bacteria varied with the pH of the soil in which they are involved. They also observed that nitrification was possible at pH 5 to pH 13. The present investigation deals with the study of the nature and extent of ammonification and nitrification in the acid Kari soils of Kuttanad.

Materials and Methods :

Three typical acid peat soil samples labelled as 'T' 'C' 'F" were taken from the Kuttanad area. Organic matter in these varied from 20-40%.

Brief outline of the methods adopted for the laboratory exminations of the soils is given below :-

(1) The pH, total nitrogen. lime requirement and water soluble sulphates and chlorides were determined by methods given in A. O. A. C. (1946).

(2) Bacterial counts on the above samples were made in (1) Thornton's agar; (2) Nutrient agar and (3) Soil extract agar.

(3) Ammonifying power of the soils was estimated by the following method.

Remys solution was prepared-25 ml. aliquots of the solutions were taken and diluted to 100 ml. and then sterilized. One gram portions of the soil samples were introduced in quadruplicate flasks and incubated at 27°C. One flask from each soil series was taken at intervals of 24 hours and ammonia estimated.

(4) The nitrifying power of soils. T, C, and F, was determined by inoculating the soils with standard Omeliansky's solution.

(5) Determination of the nitrifying capacities of acid peat soils was done by the 'perfusion technique' as described by Lees and Quastel(1946). The nitrate determinations were made by following the colorimetric method described by Lees and Quastel as modified by Chase (1948).

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Experimental Results and Discussion.

Chemical Determinations:

In table 1 is presented results of chemical determinations of the soil samples under studied.

TABLE I

Sample	*pH*	*Nitrogen* (percent)	*Lime requirement* (Tons/acre)	*Sulphate %*	*Water soluble Chloride %*
T	3.1	0.64	10.5	3.38	0.21
C	2.9	0.31	12.5	4.31	0.31
F	3.6	0.50	6.8	1.82	0.04

All the soil soil samples are of low pH range. Total nitrogen content, lime requirement, and water solubls sulphates are very high in all the samples. In spite of the high nitrogen content of these soils, the paddy plants growing on them exhibit symptoms of nitrogen dificiency. The peculiar characteristics of the soils under study can only promote the development of special types of microflora.

Microbiological Determinations :

The total counts of bacteria on the samples, in three different media are given in Table II.

TABLE II

Total Bacterial counts:

Media used	*Soil sample*	*Total counts per gram*		
		4 days	*7 days*	*10 days*
Thornton's Agar	*1*	450	460	465
	C	100	120	120
	F	2500	2800	2900
Nutrient Agar	1	300	300	320
	C	20	24	25
	F	3200	3200	3200
Soil Extract Agar	T	200	250	230
	C	30	35	35
	F	3500	3700	3700

The total bacterial counts in the soil samples are low. But there is considerable difference between the bacterial counts. The total bacterial count in soil 'C' is only 30-100 as against 300 in T and 2500-3500 in Soil 'F'.

The results of experiment to find out the ammonifying power of soils and the amount of ammonia produced by different soils upon inoculation into the soil extract ammonifying solution of the soil 'C' are presented in Tables III and IV respectively.

TABLE III.

Amount of Ammonical Nitrogen Produced.

Sample	*Period of incubation*			
	24 hrs.	*48 hrs.*	*72 hrs.*	*96 hrs.*
	mg.	mg.	mg.	mg.
T	12.4	18.9	27.3	28
C	113	23.8	27.3	28
F	8.9	20.3	25.7	27.3

It is seen that all the soils produced ammonia in quantities comparable to normal soils. All samples produced about 28 mg. of NH_3.—N after four days incubation. The amount of ammonia producted during the initial period of incubation differed in three samples. Soil 'F' produced 8.9 mg. of NH_3-N in 24 hours while Samples 'C' and 'T' produced 11.3 and 12.4 mg. respectively. It would appear that ammonifying organisms in sample 'C' and 'T' get enough energy while in sample 'F' they produce NH_3-N uniformly during the entire incubation period. One explanation for the difference is that the organism in 'C' & 'T' remained dormant and started functioning- when conditions became favourable while in 'F' the process might have been going on which might give a uniform ammonifying power.

To find out the effect of the soil extracts of these acid soils on ammonification the following procedure was adopted. Water extracts (1 : 5) of these soils were made 10 g. peptone and 5 g. sodium chloride were added to 100 ml. each of the soil extracts. Inoculations were made as follows:–

To the soil extract, ammonifying solutions of soils T, C and F and one gram of the following soils were added (1) Delhi Soil-calcareous in nature (D) (2) Ranchi Soil-slightly acid soil (R) and (3) Nagercoil Soil-alkaline fertile soil (N).

The amounts of ammonical nitrogen produced as a result of these inoculation are given in Table IV.

It may be noted from the above experiment that there is a gradual increase in nitrogen produced as ammonia as we go from *slightly acidic* soil to a *highly acidic soil.* The soils D and N were unable to produce NH_3 in soil extract of C indicating the presene of water soluble toxic substances in them.

The nitrifying power of soils, T, C, and F was determined by inoculating them with standard Omeliansky's solution. There was no nitrate production. The experiments were repeated after the following treatments.

TABLE IV.

Ammonia produced by different soils upon inoculation into soil extract, ammonifying solution of soil 'C'

Soil Sample.	*mg. of N as Ml, after incubation :*		
	48 hrs.	*12 hrs.*	*96 hrs.*
T	1.5	5.2	7.9
C	2.1	6.2	9.8
F	1.1	4.2	6.2
R	Trace.	1.6	2.9
D	Trace.	—	
N	—		

The experiments were repeated with media prepared as before with soil extract of 'T'.

TABLE V.

Ammonia Production in Soil extract by ammonifying solution of Soil T.

Soil sample:	*mg. of N as NH_3 after incubation.*		
	48 hrs.	*12 hrs.*	*96 hrs.*
1	4.2	8.4	10.7
C	4.7	9.5	12.4
F	3.8	4.9	8.4
R	1.2	2.4	3.5
D	Trace.	Trace.	Trace.
N	"	"	"

(1) Adding of fresh source of nitrogen (groundnut cake).

All the above experiments except the last produced negative results. The results indicate that these acid peat soils contain some

(3) After leaching the soil.

(4) Addition of $CaCO_3$ to leached soil.

(5) Inoculating with fresh fertile soil.

The rate of nitrification in the soils was assessed by the 'Perfusion technique' by determining the nitrate nitrogen in the perfuate at intervals of 1 to 7 days. The short time

interval was used when rates were rapidly changing. The nitrification was determined in peaty acid soils after the following treatments:-

(1) 10 g. soil was mixed with 5 g. Vermiculite to overcome puddling.

(2) 10 g. soil mixed with 5 g. Vermiculite after adding $CaCO_3$ equal to its lime requirement.

(3) 10 g. soil mixed with $Ca_3(PO_4)_2$ to supply 60 lbs. of P_2O_5 and then well mixed with Vermiculite.

(4) In another series the above soils were inoculated with nitrifying bacterial culture taken from a saturated soil column of nitrifiers. The amounts of nitrates produced are given in the following table.

Nitrification is negligible in these soils. Treatment with $Ca_3(PO_4)_2$ helps nitrification to a great degree. It is also clear that inoculation with nitrifiers after the soil has been leached may help the enhancement of nitrification.

Summary and conclusions

Three typical acid peaty soils collected from Kuttanad region were selected for the microbiological nitrogen transformation studies. The total bacterial counts ammonifying, nitrifying and nitrate forming capacities of the soils were studied in comparison with some other normal soils. The study throws much light regarding the peculiar feature of the microbial population of the acid peat soils.

TABLE VI.

Amount of NO_3—N produced by perfusion technique.

Treatment.	*Initial pH*	*mg. N produced after 10 days.*	*One month.*
Uninoculated series:			
Soil alone	4.0	20	20
Soil—$CaCO_3$	6.4	26	60
Soil—$Ca_3(PO_4)_2$	4.8	83	125
Inoculated series:			
1. Soil alone	4.0	20	62
2. Soil–$CaCO_3$	6.4	33	125
3. Soil Ca3 $(PO_4)_2$	4.8	12.88	187

From the investigation it is observed that

(a) Total bacterial count of a soil is not a measure for assessing its fertility status.

(b) Given Proper conditions the production ofammonia can beincreased.

(c) The high acidity, high salt content and high concentration of sulphates are inhibitory to important microbial activity in these soils.

(d) As seen from the results obtained from nitrification experiments the soils are devoid of bacteria capable of producing nitrates.

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