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Denitrifying Bacteria in Red and Black Soils

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The study was undertaken with the object of investigating the seasonal variations in the denitrifying bacterial population and the pattern of distribution in the various horizons of red and black soils. Observations were recorded for twelve months. The data showed that there is difference in the population in red and black soils. The cyclic variation of the denitrifiers was found to be a function of the rainfall distribution over the area. The population is most concentrated in the first 30 cm of the soil profiles and decreased with increase in depth till 90 cm. Thereafter, the population did not show variation with depth.

Waterlogged conditions after prolonged rainfall may initiate denitrification of nitrate in soils. This might contribute significantly to the nitrogen economy of the soils especially in places where the available nitrogen is a limiting factor. In South Australian black earths and red earths, it was observed (Mc Garity, 1961) that activity of denitrifiers decreased with increase in depth. When solodized solonetz profiles were examined by Mc Garity and Myers (1968) the depth distribution pattern showed strong positive correlations between denitrifying activity and organic matter and a high denitrifying activity was observed in the sub-soil horizons.

MATERIALS AND METHODS

Sampling sites were selected one each in red soil and black soil in such a way that they were away from wells and stagnating water sources. Profile samples were collected regularly on the first of every month for a period of one year from December to November. The soil samples were analysed for denitrifiers. The monthly rainfall data were also recorded. The observations made during the investigation are discussed in this paper.

RESULTS AND DISCUSSION

In Table I is furnished the denitrifying microbial population in black soils. During the period of observation, the mean population in black soil varied from about 1901 to 9046 which in red soil (Table II) varied from 536 to 6884. The variation is almost 4.8 times in black soil and 12.8 times in red soil. The cyclic variations during the different periods of the year are similar in both red and black soils (Fig. 1). Impressing the rainfall data over the population curves in Figure 1, it is seen that depressions in the denitrifiers correspond to the depressions in the rainfall data

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TABLE I. Denitrifying bacteria in black soil (in thousands)

Depth in cm	Months: Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Average	C.D (P=0.01)
0-15	15.57	20.70	18.10	8.87	18.20	16 30	17.20	17.40	23.50	8.30	6.43	10.10	15.06	
15-30	1.72	6.60	6.20	0.84	4.90	12.40	11.20	20.70	3.90	17.70	5.80	9.25	8.45	Depth 4 6
30-60	4.60	1.10	1.90	0.63	0.38	24.30	9.77	0.32	1.40	1.06	9.30	4.80	4.73	
60-83	0.27	4.00	0.60	1.25	0.51	1.67	0.85	2.30	2.33	1.80	1.30	4.00	1.74	Season 6.1
83-120	0.25	1.10	0.65	1.00	0.32	4 94	1.30	0.98	2.67	1.05	1.90	0.50	1.38	
120-150	0.82	1.30	0.34	0.36	0.74	2.65	1.15	2.04	3.27	3.20	1.10	1.47	1.54	
150-180	0.83	0.90	1.20	0.36	0.55	1.06	3.13	3.40	6.76	5.80	1.20	2.05	2.27	
Average	3.44	5.10	4.14	1.90	3.51	9.05	6.37	6.74	6.26	5.56	3.87	4.60		

TABLE II. Denitrifying bacteria in red soil (in thousands)

Depth in cm	Months: Dec.	Jan.	Feb.	March.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Average	C.D. (P=0.01)
0-15	11.88	19.10	10.50	22.44	17 50	8.92	20.50	10.50	7.64	5.50	18.80	12.65	12.16	
15-30	6.01	11.90	4.12	0.51	8 43	14.55	5.46	11.60	8.50	5.50	6.80	3.26	7.24	Depth 3.19
30 60	2.63	10.40	1.76	0.31	17.00	12.40	3.45	2.70	5.90	7.30	5.26	12 40	6.27	
60-90	4.76	2.30	1.63	0.26	1.63	2.89	2.56	6.00	1.06	2.10	2.80	2.20	2.52	
90-105	0.50	2.10	1.04	0.19	2.27	1.72	3.00	2.10	1.65	2.64	1.10	2.70	1.75	Season 3.91
105-120	0.54	1 40	1.34	0.25	2.70	3.38	3.64	2.66	0.54	3.16	1.00	2.40	1.92	
120-150	2.03	1,30	0.93	0.08	2.54	3.18	2.08	2.13	1.36	2.52	1.10	2.30	1.80	
150-180	4.13	1.30	0.74	0.25	3.00	1.03	3.34	2.89	0.73	2.73	1.10	2.20	1.95	
Average	4.06	6.23	2.76	0.54	6.88	6.01	5.50	5.07	3.42	3 11	4.75	5.01		

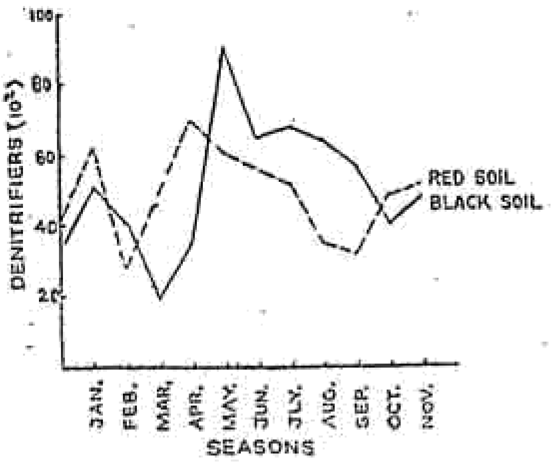

Fig. 1. Seasonal variation of denitrifiers

and vice versa. This phenomenon is evident from the fact that during rainy seasons the soils are either saturated with rain water or wet enough to promote denitrification process, since denitrification of nitrate occurs under anaerobic or mostly anaerobic conditions. Lazeno Calle (1968) observed denitrifying activity in soils of Toledo (Spain) to be minimum in summer and winter but maximum in spring.

Scattered diagram of Y (denitrifying organisms) with X (moisture content of the soil) was constructed. This did not indicate any trend. Then scatter of Y with log X, X with log Y and log X with log Y was constructed. Of all these the scatter of X with log Y alone gave a more or less linear trend. Therefore, the equation of the form $Y = ab^X$ was fitted. Since logarithm to the base 10 were used 'b' was taken as 10. Hence, the equation is of the form $Y = a10^X$. In the case of black soil, the equation is $Y = 53.79 \times 10^{-0.0441X}$ and in the case of red soil, it is $Y = 24.05 \times 10^{-0.0706X}$

Differentiating the two fitted equations with respect to variable present, we have

$dy/dx = (-2.372).\ 10^{-0.0441X}$

for black soil (i) ....

$dy/dx = (1.697)\ 10^{0.0706X}$

for red soil (ii) ....

From the equation (i) it is inferred that the bacterial population is a decreasing function of the moisture content in the case of black soil. Probability of the above trend lies in the fact that the mineralogical composition of the black soils is such that they expand in volume under very high moisture conditions and are very plastic to the extent of destroying the porespaces even. The equation (ii) for red soil indicates an increasing function of the moisture content. Red soil examined in this study was loamy in texture and an increase in moisture content might well initiate anaerobic conditions suitable for the denitrification activities. The mineralogical make up of red soils is not similar to that of black soils to register a decreasing trend under very high moisture content.

The average denitrifiers in the plough layers were more than the subsequent lower horizons (Fig. 2). Similar results were obtained by Mc Garity (1961). In the present study, the population of the organisms in the 0.5 cm layers was always higher in the black soils than in the red soils. This may probably be due to the higher moisture content in black soils (ranged from 2.7 to 6.2 per cent with an average value of 4.4 per cent) than in the red soils where the moisture percentage ranged from 1.2 to 6.3 with an average of 2.1. In red soils, 54.5 per cent of the total denitrifiers are found in the first 30 cm layers of the soils and the rest were distributed among the lower horizons. In the black soils, 66.4 per cent of the populations were found in the corresponding upper horizons while 33.6 per cent were distributed in the lower horizons.

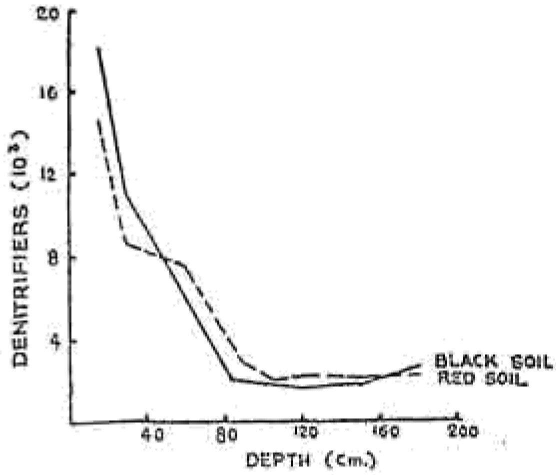

Fig. 2. Depth function of denitrifiers

Focht and Joseph (1973) reported the distribution pattern of denitrifying bacteria in profiles of two different soils and observed a logarithmic decrease with depth. Similar results were reported by Mc Garity (196) and Mc Garity and Myers (1968). The depth distribution of the denitrifiers of the present investigation is illustrated in figure 2. It could be seen that there is almost a steep decrease of the population till a depth of 90 cm in both the soils and thereafter the variation in the population is not statistically significant and is independent of the depth.

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