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EFFECTS OF ADDING NICKEL (AS OXIDE) TO SOIL ON NITROGEN AND CARBON MINERALISATION AT DIFFERENT pH VALUES

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ABSTRACT

Nitrogen and carbon mineralisation were measured after adding 50, 250, 1000 *and* 5000 *ppm Ni (as oxide) to a sandy soil at pH levels of* 5·8, 6·9 *and* 7·6 *(the last containing* 1% *calcium carbonate) and incubating aerobically for six weeks at* 30 °*C. Nitrification decreased to a greater extent with increasing Ni at pH* 5·8 *than at pH* 6·9 *and* 7·6. *Nitrogen mineralisation decreased to about the same extent with increasing Ni at all pH levels. Carbon mineralisation decreased with increasing Ni to about the same extent at pH* 5·8 *and* 6·9 *but to a lesser extent at pH* 7·6.

INTRODUCTION

Contamination of soil by Ni compounds may occur through application of mining, industrial and sewage wastes, commercial fertilisers and also by air-borne pollution from industrial smokes and fossil fuels. A review by Swaine (1955) shows that whereas most soils contain Ni levels ranging from traces up to about 1000 ppm, soils derived from ultra-basic rocks (e.g. serpentine) may contain up to 5000 ppm Ni. In a previous paper (Giashuddin & Cornfield, 1978) an incubation study was reported on the effects of adding 10 to 1000 ppm Ni (as sulphate) to a sandy soil (pH 5·9) on mineralisation of N and C. The present paper reports the effects of 50–5000 ppm Ni (as oxide) on the mineralisation of N and C by a sandy soil adjusted to three different pH values.

MATERIALS AND METHODS

Nickel oxide was prepared by igniting AR nickel nitrate at 800 °C. The product

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contained 74·4 % Ni which is very near the theoretical value of 74·7 %. 3·1 % of the NiO was soluble when shaken with water and 3·2 % when shaken with *N*-potassium chloride. The soil used was a 'Bagshot' sand sampled from the top 23 cm of the 'Shedfield' series in south-east England and was air-dried at room temperature and ground to pass a 2 mm sieve. It contained 82·0 % sand, 9·8 % silt, 5·2 % clay, 2·1 % organic C, 0·18 % total N, 36·8 ppm ammonium-N, 27·0 ppm nitrate-N and had a pH (in water) of 5·8. The soil contained 8·1 ppm total Ni and 0·2 ppm Ni extractable by *N*-potassium chloride. Three 1 kg batches were prepared—the original soil, the original soil mixed with 1·4 g finely ground calcium carbonate and the original soil mixed with 11·4 g calcium carbonate. These quantities were added on the basis of preliminary tests in order to obtain one soil of pH about 7 and another containing 1 % free calcium carbonate. The three 1 kg batches were placed in pots and water was added to 50 % saturation. The pots stood for two months at room temperature, with water being added to maintain moisture content between 40 % and 50 % saturation. The soils were then air-dried and rubbed through a 2 mm sieve. The three soils then had pH values of 5·8, 6·9 (no free calcium carbonate) and 7·6 (1 % free calcium carbonate). Batches of soils of each pH were mixed with finely ground NiO to supply 50, 250, 1000 and 5000 ppm Ni. For incubation 10 g samples, in duplicate, of treated soils and control soil (no NiO added) were placed in 10 × 2·5 cm diameter glass tubes and water was added to bring the moisture content to 50 % saturation. The barium peroxide method (Cornfield, 1961) was used for aeration and absorption of carbon dioxide during incubation. The tubes were closed with rubber bungs and incubated for six weeks at 30 °C. For analysis of the samples after incubation, 10 ml of water was added to each tube and pH measured after shaking. Then 10 ml of 2N potassium chloride was added and, after shaking, the contents were centrifuged and suitable aliquots of the supernatant liquid analysed for ammonium- and nitrate-N by a microdiffusion method (Bremner, 1965). The potassium chloride extracts were analysed for Ni by atomic absorption spectroscopy.

RESULTS AND DISCUSSION

Results are shown in Table 1. The accumulation, during incubation, of mineralised N entirely as nitrate at pH values of 6·9 and 7·6 indicates that conditions were aerobic. The accumulation of some ammonium-N at pH 5·8 is due to restricted nitrification at this relatively low pH.

After incubation the pH of each of the three soils at each Ni level differed by less than 0·2 units from the corresponding initial pH values.

In all three soils mineral-N and nitrate accumulation during incubation decreased with increasing levels of applied Ni. With the 5000 ppm treatment, mineralised N decreased by 37 %, 27 % and 35 % and nitrification decreased by 66 %, 29 % and 30 % in the soils of pH 5·8, 6·9 and 7·6, respectively. Ammonium-N accumulated at pH

TABLE 1

EFFECTS OF SOIL pH AND LEVEL OF ADDED NICKEL (AS OXIDE) ON MINERAL NITROGEN ACCUMULATION,[a] CARBON DIOXIDE RELEASE AND EXTRACTABLE NICKEL AFTER SIX WEEKS OF AEROBIC INCUBATION AT 30 °C (RESULTS ON DRY SOIL BASIS)

Treatment Ni (ppm)	*Mineral nitrogen* NH_4-*N (ppm)*	NO_3-*N (ppm)*	*min-N (ppm)*	CO_2 *release (ppm)*	*N-KCl extractable Ni (ppm)*
Soil pH 5·8					
0	5	41	46	3215	0·2
50	8	34	42	2500	0·4
250	10	27	37	2400	0·6
1000	13	18	31	2147	1·1
5000	15	14	29	2010	2·5
Soil pH 6·9					
0	−3[b]	58	55	3660	0·4
50	−2	51	49	2980	0·4
250	−2	47	45	2470	0·8
1000	−1	44	43	2340	1·1
5000	−1	41	40	2230	2·4
Soil pH 7·6 (and containing 1 % free $CaCO_3$)					
0	−1	50	49	2890	0·4
50	−2	46	44	2620	0·4
250	−2	40	38	2570	0·6
1000	−3	38	35	2210	1·0
5000	−3	35	32	2030	2·0
LSD $p < 0·05$	1·5	2·0	3·4	80	0·3

[a] Initial levels subtracted from those after incubation.
[b] Negative values indicate less ammonium-N after incubation than initially.

5·8 and increased with level of applied Ni. There was no ammonium-N accumulation at pH 6·9 and 7·6, the mineralised N accumulating entirely as nitrate. A greater decrease in nitrification due to increasing added Ni occurred at pH 5·8 than at the two higher pH levels, between which there were only small differences. This indicates that at pH 5·8 the nitrifying organisms were more susceptible to increasing Ni levels than were the N-mineralising organisms. At pH 6·9 and 7·6, on the other hand, nitrification and N mineralisation decreased to about the same extent with increasing Ni levels. There was no ammonium-N accumulation in the control soil or at any Ni level in soils of pH 6·9 and 7·6, indicating that nitrification was being limited by N mineralisation.

At each pH level C mineralisation (CO_2 release) decreased with increasing level of applied Ni. The decrease was somewhat greater at pH 5·8 and 6·9 than at pH 7·6. With 5000 ppm added Ni, exchangeable Ni was somewhat lower in the calcareous than in the other two soils. This would tie in with the finding that CO_2 release was least adversely affected in the calcareous soil. There were only rough correlations ($p < 0·2$) between decreasing mineral-N forms and C mineralisation in relation to increasing applied Ni. A very small fraction (less than 1 %) of the Ni applied as oxide was in exchangeable form at all pH levels with all levels of applied Ni.

The only data available for comparing the effects of Ni as oxide (present study) and as sulphate (Giashuddin & Cornfield, 1978) showed, at pH 5·8 with 1000 ppm Ni, that N mineralisation, nitrification and carbon mineralisation were decreased to about the same extent with both forms of added Ni. This suggests that the reactions with the soil of the completely soluble $NiSO_4$ and the slightly soluble NiO produced conditions which were very similar with respect to their effects on N and C mineralisation.

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