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IS NITRATE REDUCED TO AMMONIUM IN WATERLOGGED ACID SULFATE SOIL?

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Key words

Ammonium Ferrous iron Nitrate reduction Reduced soil

Summary

A study of transformations of added nitrate nitrogen in an acid sulfate soil under waterlogged conditions indicated that chemical reduction of NO_3–N to NH_4–N is effected by high concentrations of ferrous iron, released in the soil following flooding and reduction of ferric to ferrous iron.

Introduction

Little is known about the chemical reduction of nitrate to ammonium in soils though it would be important in wetland rice soils, especially those that release high amounts of Fe^{2+} in soil solution after flooding. Reduction of nitrate to N_2 and N_2O gases has been investigated by Buresh and Moraghan[7]. Bremner and Shaw[6] reported that reduction of nitrate to ammonium was effected by ferrous hydroxide when it was treated with ferrous sulfate and magnesium oxide. Based on this reduction Bremner and Bundy[7] proposed a method for the determination of nitrate in soil extracts by distillation with ferrous sulfate and MgO.

The objective of this work was to study the reduction, if any, of nitrate–N to ammonium by ferrous iron released in a flooded acid sulfate soil. Most acid sulfate soils release high amounts of iron in soil solution when flooded and provide an opportunity to test the occurrence of this process.

Materials and methods

The soil used in the study is an acid sulfate soil, Calalahan sandy loam from Bicol, Philippines. The soil was air-dired and ground to pass a 2-mm sieve. Important properties of the soil are given in Table 1. For soil analysis, pH was measured by a glass electrode; organic carbon analysis was done by Walkley and Black[10] method and total N was determined by the method described by Bremner[3].

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Table 1. Properties of the soil used

Property	Value
pH (1 : 1)	3.4
Sand, %	79.0
Clay, %	5.0
Organic matter, %	2.7
Total N, %	0.110
NH_4^+-N, ppm	22.0
NO_3^--N, ppm	0.0
Active iron, % (ref.[1])	1.44
Active Mn, % (ref.[1])	0.002

NH_4-N and NO_3-N were determined following the extraction and distillation method of Bremner[4]. Active iron and Mn content in the soil were determined by the method of Asami and Kumada[1] and particle size analysis was performed by the hydrometer method[8].

Incubation method

Duplicate 10 g soil samples were incubated under flooded conditions with 20 ml of distilled water in 125 ml flasks with their mouths covered with aluminium foils. Half of the flasks were unamended and the remaining half were amended with 100 ppm of nitrate and incubated at 30°C. Samples were daily taken and analysed for NH_4^+ and NO_3^- by extraction with 2 *M* KCl and distillation of the filtered extracts with MgO and Devardas alloy[4].

Results and discussion

Denitrification of added NO_3^--N was slow; 70% of 100 ppm NO_3-N added could be detected in the soil after 7 days of incubation (Table 2). No nitrate could be detected in the unamended soil and NH_4^+ accumulated in all soil samples.

It is further indicated from the results (Table 2) that with the addition of NO_3-N in the soil, there was an increase in the amounts of NH_4^+ recovered. After 7 days, 16% more NH_4^+ was recovered in the soil samples treated with nitrate nitrogen. These results indicate the possibility of conversion of nitrate to ammonium in flooded acid sulfate soil that release high amounts of Fe^{2+} in soil solution. Earlier studies[9] have shown that this soil releases as much as 3450 ppm of Fe^{2+} in solution within a few days of flooding. Thermodynamically, the reduction of NO_3^- to NH_4^+ is favoured by the Fe^{2+} activity of reduced soils.

$$NO_3^- + 8\ Fe^{2+} + 21\ H_2O = NH_4^+ + 8\ Fe(OH)_3 + 14\ H^+$$

The equilibrium constant (at 25°C and 1 bar pressure) for this reaction works out to be $10^{-23.69}$ using free energy data from Berner[2].

Preliminary results of this study indicate the possibility of reduction of NO_3^- to NH_4^+ in presence of Fe^{2+} in flooded soils that release higher amounts of Fe^{2+} in solution. There is an obvious neeed for confirming theses results using labeled nitrate nitrogen.

Table 2. Transformation of NO_3–N in a flooded acid sulfate soil. Figures show 2 *M* KCl extractable NH_4^+ and NO_3^- in ppm

Treatment		0	1	2	3	4	5	7
Soil alone	NH_4^+	22	28	33	45	52	60	63
	NO_3^-	0	0	0	0	0	0	0
Soil + 100 ppm NO_3^-	NH_4^+	22	35	44	58	65	75	79
	NO_3^-	101	90	84	80	78	74	70
Excess NH_4^+ produced (ppm) due to NO_3^- treatment		0	7	11	13	13	15	16

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