Indexes of assessing N availability in sewage sludges

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Abstract

Biological and chemical methods were used in an attempt to estimate N availability in sewage sludges. The two biological methods, i.e. maize plants grown in pots, and soil-sludge mixtures incubated at 2, 4, 6, 8, 12 and 16 weeks, and the four chemical methods, i.e. autoclave, 0.5 M KMnO₄, pepsin and 0.6 M HCl, were compared to determine N availability in twelve sewage sludges in a given soil. In the mineralization test, the aerobically treated sewage sludges gave higher mineralization rates than the anaerobically treated wastes. The simple correlation between available N, estimated from the plant N uptake during 6 weeks and N extracted by chemical methods showed that HCl and pepsin appeared to be the better single indexes. Prediction of availability of N in sewage sludges to plants in the growth chamber improved if N mineralized during the incubation period and extracted by several chemical methods were combined in a multiple regression analysis.

Introduction

Recycling organic wastes through agricultural land application is an old practice that has received renewed interest in recent years due to the water pollution concern and the need for low-cost disposal of large quantities of municipal organic wastes. The amount of sewage sludge applied to agricultural land is often based upon the N content or the availability of N in the waste to plant (Premi and Cornfield, 1971; Ryan et al., 1973). Because most of the N in sludge is organic (King and Morris, 1972; Magdoff and Chromec, 1977; Mitchell et al., 1978; Ryan et al., 1973; Sommers, 1977) more information about the rate of N mineralization is required to predict N availability during a cropping season.

Numerous laboratory studies have been conducted to determine the rate and extent of sewage sludge mineralization in soil. The results vary widely, because of differences in sewage sludge sources (Beauchamp et al., 1979), treatment processes (Chaussod and Germon, 1977; Epstein et al., 1978; Magdoff and Chromec, 1977; Tester et al., 1977), applied rates (Premi and Cornfield, 1969; Ryan et al., 1973), and laboratory procedures employed (Parker and Sommers, 1983). Generally, procedures involving the determination of N mineralized during incubation are considered the most satisfactory ones of methods currently used to calculate N availability indexes (Castellanos and Pratt, 1981a; Loewen-Rudgers et al., 1981; Magdoff and Amadon, 1980; Parker and Sommers, 1983). However, incubation procedures are quite laborious and time-consuming, and therefore, many rapid and convenient chemical extraction procedures providing suitable indexes of N availability have been proposed (Castellanos and Pratt, 1981b; Magdoff and Amadon, 1980; Parker and Sommers, 1983). The relative usefulness of any chemical index depends on the degree to
which the data correlate with those of reliable biological measurements of N availability, e.g. N uptake by plants or mineralizable N.

The objectives of this study were to evaluate chemical methods of assessing N availability via regression analysis with total N uptake by maize (Zea mays L.) grown in a growth chamber and with N being mineralized during incubation.

**Materials and methods**

**Soil and sludges**

Aerobically and anaerobically digested sewage sludges were obtained from different Spanish sewage treatment plants. The soil materials employed were taken from a surface layer of 0–15 cm. Soil and sewage-sludge samples were air-dried and ground to pass a 2-mm sieve. Some properties of the soil and sludges are given in Table 1.

**Incubation procedure**

The different sludges were mixed with soil at the rate of 50 mg ha⁻¹ (28 g kg⁻¹ soil). The samples were incubated aerobically during 16 weeks at 25°C; the moisture content was adjusted weekly to about 2/3 of field capacity.

Mineralized N (NH₄⁺, NO₃⁻ + NO₂⁻) was determined after 2, 4, 6, 8, 12 and 16 weeks of incubation, using the non-leaching procedure. In each case three replicates of each soil-waste mixture and a non-amended control soil were analyzed. The extractant employed was 2 M KCl at a soil-sludge-to-extractant ratio of 1:5.

**Growth chamber experiment**

Maize plants were grown in a culture chamber at a 22°C day/16°C night temperature regime and 16 h photoperiod over a period of six weeks. Plants were grown in pots containing 1 kg of soil, and sludges at an equivalent rate of 25 mg ha⁻¹ (14 g waste kg⁻¹ soil), amended with 700 kg ha⁻¹ of 0/24/12 fertilizer (0.38 g fertilizer kg⁻¹ soil). An unamended soil was included as control. The pots were irrigated twice weekly. After a six-week period of cultivation, the plants (including roots) were harvested and washed with distilled water.

All harvested plants were oven-dried at 60°C, weighed, ground in a stainless steel mill, and stored at 4–5°C before analysis.

**Chemical analyses**

Total N in plant, soil and sludge samples were determined with the semi-micro Kjeldahl method, with salicylic acid employed to include nitrates (Bremner, 1965a). NH₄⁺ and (NO₃⁻ +...