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Extraction of Plant Available Nutrients in, Algal Pond Effluent

Muhammad Ayyaz Khan and T.H. Flower¹

Department of Agronomy, Faculty of Agriculture, Gomal University, Dera Ismail Khan, NWFP, Pakistan

¹Department of AFE, University of Glasgow, G12 8 QQ, Scotland, UK

Abstract: The selection of a suitable extractant for measuring available nutrients in the algal pond effluent was the aim of this study. Chemical composition of algal pond effluent in relation to its ability to supply plant available nutrients was evaluated using four extracts. The results revealed that ammonium phosphate and potassium should be measured in 0.1 M HCl extracts while nitrite and nitrate can be measured by direct filtration.

Key words: Extraction, nutrients, algal pond effluent

Introduction

Selection of a suitable extracting solution for the determination of the available nutrients in animal wastes depends upon the nutrients to be determined in the extracts and also on the instrument used in their determination. Various extracting solutions have been used for extraction of the available nutrients from animal wastes. Hoyle and Mattingly (1954) have used dilute hydrochloric acid (0.1 M HCl) to extract soluble nitrogen from compost. Byrne and Power (1974) suggested that ammonium nitrogen can be extracted with dilute 0.1 M HCl from animal slurries. Rowarth *et al.* (1985) determined extractable phosphorus in the extracts obtained by shaking of 1 g of sheep dung with 40 ml of the distilled water. Whitehead *et al.* (1989) extracted the ammonium-N from cattle and pig slurries with 1 M KCl. Kirchmann (1990) used 0.27 M, 1.76 M and 12.5 M sulfuric acid in the extraction studies on poultry excrement labelled with ⁶N. Paul and Beauchamp (1993) determined the ammonium-N and nitrate-N in 2 M KCl extracts of liquid dairy cattle manure, solid beef cattle manure.

Keeping in view the differences in the extractant used in the farm animal wastes studies, it was, therefore, decided to conduct a study of the measurement and extraction of nitrogen, phosphorus and potassium from algal pond effluent comparing 0.1 M HCl, 0.05 M H₂SO₄, 0.05 M sodium sulphate and water as extractant along with a direct filtration of effluent.

Materials and Methods

An experiment was conducted in the Department of AFE, University of Glasgow during 1993. Samples of algal pond effluent were collected from small scale 2 m² surface area, high rate algal ponds run by the Department of Biochemistry of the Scottish Agricultural College under controlled conditions in the green house at Auchincruive, Ayr. The samples were stored in the cold room at 2°C. Hydrochloric acid (0.01 M), 0.05 M H₂SO₄, 0.05 M sodium sulphate were prepared. Water was also used as extractant. Sodium sulphate was purified from ammonium impurities (Khan, 1987). Filter papers used in the filtration were washed (Shah, 1988).

The algal pond effluent was extracted with four extractant along with direct filtrate of the effluent. The stock of the algal pond effluent was stirred using a magnetic stirrer. Ten g of algal pond effluent was weighed into 100 ml plastic bottles using four replications and blanks for each treatment. Ninety ml of each extractant was added to these bottles. The blank bottles contained 100 ml of the extractant. The bottles were tightly capped and were shaken for one hour on an end-over-end shaker at room temperature. The solutions were then filtered through washed whatman No. 1 filter papers. The filtrate was collected into 100 ml plastic bottles and stored at 2°C until analysis. Ammonium nitrate, nitrite and phosphate was determined by using technique

AutoAnalyzer-11. Ammonium was determined by the method of Brown (1973). Nitrate and nitrite were measured by the method (Best, 1976). Phosphate was measured by the method based on the formation of a phospho-molybdate complex which is reduced by ascorbic acid to give a blue colour measured at 880 nm. The potassium was determined by using a corning EEL flame photometer.

Results and Discussion

Results given in Table 1 showed that 0.1 M HCl extracted significantly more available ammonium nitrogen than the other extracts. It did not differ significantly from the ammonium measured in the direct filtrate. No difference in the nitrate level extracted by 0.1 M hydrochloric acid and 0.05 M sulfuric acid was observed. However, the direct filtrate gave a significantly lower amount of nitrate compared with all the extracts. Either extract or direct filtrate can be analysed for the measurement of available nitrogen.

Table 1: Available nutrients in extracts and direct filtrate of algal pond effluent

Extractant/filtrate	Nutrients			
	NH ₄ ⁺ -N	NH ₃ ⁺ -N	PO ₄ ³⁻ -P	K
0.1 M HCl	11.4c	10.3a	10.7b	10.6b
0.05 M H ₂ SO ₄	11.3c	76.9bc	76.5b	78.0d
0.05 M Na ₂ SO ₄	77.7cd	75.0a	13.7cd	13.9d
Deionized water	12.2a	12.9b	13.4c	60.4b
Direct filtrate	61.7c	58.1a	60.5b	60.2b

Figures in a column with the same letters following are not significantly different at 5% level using a Fisher's LSD Test

The available phosphate in extracts and direct filtrate shown in Table 1 reveal that 0.1 M HCl extract and direct filtrate had similar concentration of phosphate, 0.05 M sulfuric acid extracted slightly more phosphate. However, it did not differ significantly from the phosphate figure of 13.7 mg/l found in the 0.1 M hydrochloric acid extract. Evidently, 0.1 M hydrochloric acid, 0.5 M sulfuric acid extraction or direct filtration can be adopted for phosphate determination in the algal pond effluent.

It is clear from the potassium results that 0.05 M sodium sulphate significantly was the poorest extractant in extracting available potassium. Direct filtration, water and 0.1 M hydrochloric acid extracts showed similar potassium concentrations. The 0.05 M sulfuric acid extracted significantly more potassium than the other extractant used.

It can be deduced from these results that extracts of treated effluent with dilute acids or sodium salt solutions showed similar levels of ammonium, phosphate and potassium which are not different to levels of ammonium, phosphate and potassium

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extracted by water. This evidence of the inability of the effluent to hold these nutrients in the solid fraction. This matter of nutrient binding clearly differs from that found in soils where the nutrient holding is so strong that extraction with water or even a sodium salt solution is unable to remove all ammonium and potassium: Nitrate is free in soil solution and may be extracted with water. Phosphate is very strongly held by soil surfaces, therefore, extracting solutions such as acetic acid or sodium bicarbonate, buffer are required for its extraction.

Nitrogen, phosphate and potassium distribution in liquid and solid portions of animal slurries would also be different to the treated effluent tested here. For example, water soluble ammonium nitrogen in pig slurries was on average 80 percent of ammonium nitrogen extracted by 0.1 M hydrochloric acid in an experiment conducted by Byrne and Power (1974). The treated effluent fed by synthetic pig waste has free cations and anions and is a different material from algal pond effluent fed by real animal wastes. Acids or salt solutions will be needed for extraction and measurement of ammonium, phosphate and potassium in algal pond effluent.

The calorimetric methods of analysis require clean and colourless solutions. The rate of filtration and the colour of the filtrate are two more important considerations in the selection of a suitable extractant. Hoyle and Mattingly (1954) decolourised some extracts with hydrogen peroxide in nitrate measurement by calorimetric estimation with phenoldisulphonic acid. In the present study, acid extracts proved better than 0.05 M sodium sulphate and water due to their flocculating nature. As far as chemical interferences during the measurement of ammonium, nitrite, nitrate and phosphate by calorimetric methods are concerned, this problem can be solved by dilution of the extracts with water. Nitrite can not be measured in acid extracts as it is unstable under these conditions. The direct filtrate of the effluent can be analysed for nitrite and nitrate content without any problem. The results of the present study are also in accordance with those of Kirchmann (1990) who used sulfuric acid in the extraction study on poultry excrements labelled with ^{16}N .

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