Journal of Microbiology and Biotechnology
Vol. 3, No. 3, 214-216, 1993

NOTE

Removal of Inorganic Nitrogen and Phosphorus from Cow's Liquid Manure by Batch Algal Culture

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Cow's liquid manure (CLM), an animal waste, was treated by a batch algal culture to remove inorganic nutrients. CLM used in this study was especially high in concentrations of inorganic nitrogen and phosphorus. The optimum dilution ratio of the CLM for maximum algal growth was 1:25. Ninety five percent of inorganic nitrogen and 100% of inorganic phosphorus were removed from the CLM with a dilution ratio of 1:25.

Complete removal of inorganic nitrogen and phosphorus in wastewater treatment is strongly desired for the prevention of eutrophication. The main purpose of tertiary treatment is to remove inorganic nutrients from the secondary treatment effluent. There are 2 kinds of tertiary treatment; a physico-chemical treatment and an advanced biological treatment. Chemical coagulation and filtration, ammonia stripping, ion exchange and chlorination belong to the former type of tertiary treatment. Algal culture and nitrification-denitrification belong to the latter type (10, 11).

Multi-stage processes could be required for co-removal of inorganic nutrients when cow's liquid manure (CLM) is to be treated by a physico-chemical treatment. Whereas, an advanced biological treatment is able to remove inorganic nutrients in CLM simultaneously and could be a substitute for a physico-chemical one in CLM treatment (9). Algal culture has been reported to be very efficient in co-removal of inorganic nutrients. Goldman and Ryther (5) obtained virtually a complete removal of inorganic nitrogen and a 50% removal of inorganic phosphorus with a secondary treatment effluent in a batch culture. When the system was operated in a continuous mode, the amount of nitrogen removed was reported to decrease to 50~60% (5). However, reports on application of algal culture to remove inorganic nutrients in CLM are scarce. In this study, a removal of inorganic nitrogen and phosphorus from CLM was attemped by growing a mixed population of algae, as an initial step of CLM treatment using food chain and chemical coagulation.

Microorganisms

To establish an open culture system, a natural population of algae which were taken from a pond in Kyunghee University (Seoul, Korea) were used as the inoculum. *Chlorella* and *Scenedesmus* were the prevalent genus in the inoculum and were also predominant during algal culture.

Sewage

CLM was taken from local Holsteins in polyethylene carboys, immediately transported to the laboratory and then stored in a refrigerator at 4℃ till use. As shown in Table 1, most of the nitrogen in the CLM was present in inorganic forms, chiefly as NH_3-N. Most of the phosphorus was also present as orthophosphate.

Analytical Techniques

Ammonia-, nitrate- and kjeldahl nitrogen, ortho- and

Table 1. Composition of the cow's liquid manure

Component	Concentration (mg/*l*)
NH_3-N	4200~ 7500
NO_3-N	30~100
Kjeldahl-N	4400~7800
Orthophosphate	50~230
Total phosphate	100~260
COD	6000~15600

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Key words: Nitrogen removal, Phosphorus removal, batch algal culture

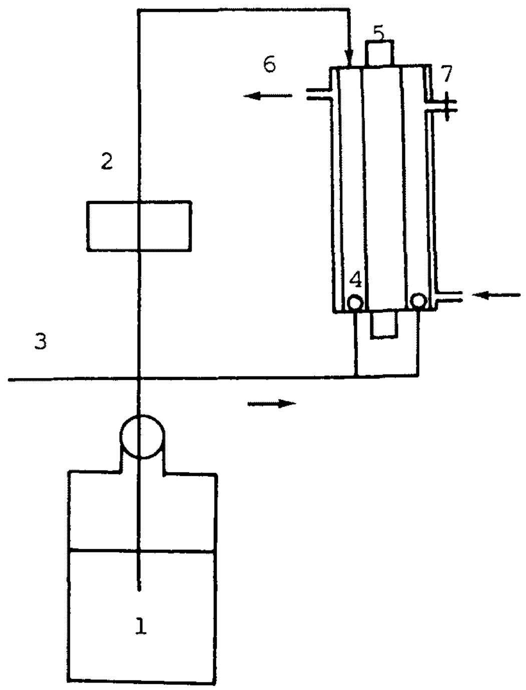

Fig. 1. Schematic diagram of the batch algal culture system.
1, medium reservoir; 2, peristaltic pump; 3, compressed air; 4, air-diffusing stones; 5, fluorescent lamp; 6, water-recycling line; 7, stopcock.

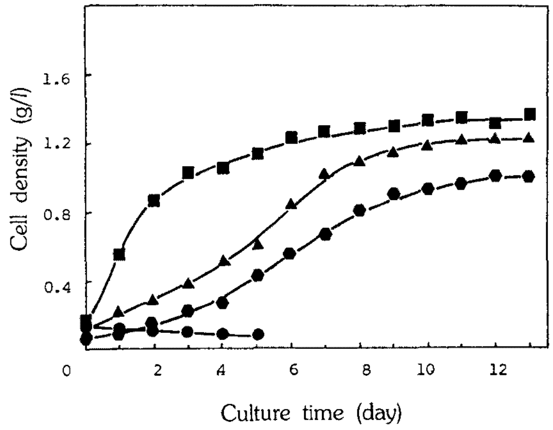

Fig. 2. Effects of dilution ratio of cow's liquid manure on algal growth.
Dilution ratio: (●), 1:10; (■), 1:25; (▲), 1:50, (●), 1:100.

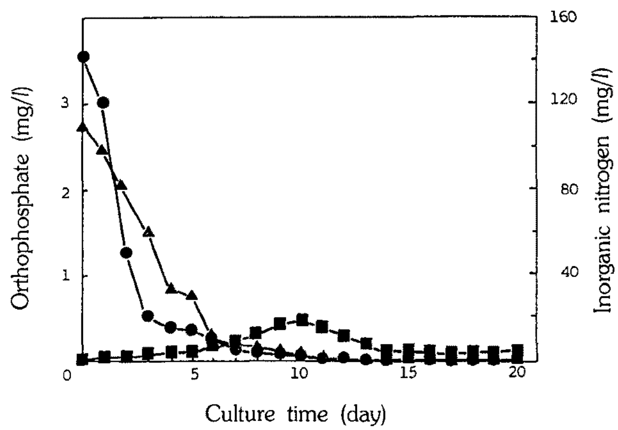

Fig. 3. Changes of inorganic nutrients during the batch algal culture of cow's manure in 1:25 dilution.
(●), NH_3-N; (■), NO_3-N; (▲), orthophosphate.

total phosphate, chemical oxygen demand (COD) and cell density were analyzed as reported in the "Standard Methods for the Examination of Water and Wastewater" (2).

Algal Growth System

A culture vessel, prepared by uniting acryl columns of 0.2 cm thickness and 40 cm height with outside diameters of 5.2, 10.0 and 12.5 cm, was used for this purpose (Fig. 1). A 40-watt cool white fluorescent lamp with a surface light intensity of approximately 930 ft-c (10000 lux) was mounted inside the culture vessel. At the bottom of the vessel, 4 air-diffusing stones were installed, through which compressed air for mixing and CO_2 was supplied at the rate of 4 *l*/min. Temperature was maintained by circulating tap water which was adjusted to 25℃. The CLM medium was initially added to the unit with a Cole-Parmer peristaltic pump (Chicago, Illinois). When the unit was filled with the medium, the medium delivery was stopped and 1% algal inoculum added. Then, incubation was continued for 13~20 days.

Algal Culture of CLM at Varying Dilution Ratios

As a preliminary step of algal culture of the CLM medium, a proper dilution ratio of the original CLM was determined (Fig. 2). As shown in Fig. 2, CLM at a dilution ratio of 1:25 (one part of the original CLM added to 25 parts of distilled water) gave the best growth of algae, amounting to a cell density of 1.3g/*l* after 12-day incubation, whereas no growth occurred at a dilution ratio of 1:10. It is presumed that an inhibition of the algal growth takes place in the CLM of 1:10 dilution ratio. The inhibiting factor could be ammonia toxicity because NH_3-N is the major inorganic nutrient in the CLM. (1, 13). In accordance with the increase in algal biomass, the total COD reached to 2000 mg/*l* after a 12-day incubation at 1:25 dilution. However, an initial drop in the total COD was found during the first 2 days, which suggests an uptake of dissolved organics by algae, in addition to photosynthesis (4).

Changes of Inorganic Nitrogen and Phosphorus during Algal Culture

The original CLM was diluted at the ratio of 1:25 and the changes in the inorganic nutrients during algal culture were measured (Fig. 3). A complete removal of NH_3-N was observed after a 13-day incubation. Nitrate nitrogen was parabolically changed. The parabolic change in the NO_3-N seems to suggest that the degree of a nitrification of NH_3-N to NO_3-N is greater than those of possible algal assimilation and denitrification during the first 10 days (3, 9). The initial inorganic nitrogen of 143 mg/*l* was reduced to 7 mg/*l* after the culture, which corresponds to a removal efficiency of 95%. Orthophosphate in the 1:25 CLM was completely (100%) removed after the whole process. The efficiency in the removal of inorganic nutrients obtained here is considerably higher than that obtained with Tamiya's medium which is an artificial medium for algal culture (7). The resulting algal biomass could be used to grow marine invertebrates, such as *Daphnia*, which have good nutritional values (6, 8, 12).

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(Received July 9, 1993)