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(54) **EFFICIENT FERTILIZER AND
ENZYME-ASSISTED METHOD OF
PRODUCTION**

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(57) **ABSTRACT**

Slow-release fertilizer is produced by composting animal manure with a magnesium-rich compound The temperature of this mixture is maintained at 20-30° C. and the pH is maintained between 7-10. Urease is added to the mixture. Next, the mixture is inoculated with bacteria of the species *Bacillus sphaericus*, *Bacillus globisporus*, or *Bacillus fusiformis*. The mixture is then allowed to incubate for about 14 days to form magnesium ammonium phosphate. Optionally, phosphatase, an enzyme promoting the formation of phosphate from phosphorus-rich organic compounds, is added with the urease enzyme to increase the yield of magnesium-ammonium phosphate.

EFFICIENT FERTILIZER AND ENZYME-ASSISTED METHOD OF PRODUCTION

GOVERNMENT INTEREST STATEMENT

[0001] The invention described herein may be manufactured, licensed and used by or for governmental purposes without the payment of any royalties thereon.

I. BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] This invention relates to an improved process for producing a slow-release fertilizer from animal waste. Specifically, it relates to a process for composting animal manure with a magnesium-rich compound and selected enzymes that form ammonia from urea and uric acid, and phosphates from phosphate-rich organic compounds. In addition, bacteria selected from guano fertilizer may be incorporated with the enzyme-manure mixture to form magnesium ammonium phosphate.

[0004] 2. Prior Art

[0005] The formation of ammonium magnesium phosphate hexahydrate assisted by bacteria has been reported by Nabil Ben mar et al., *Chemosphere*, vol. 36, No. 3, p 475-481, (1998). The removal of phosphate from supernatant liquors from anaerobically digested sludge by formation of struvite (magnesium ammonium phosphate) is reported by Battistoni et al., *Wat. Res.*, Vol. 31, No. 11, pp. 2925-2929, 1997. The formation of struvite by *Azobacter* in chemically defined media has been described by Rivadeneira et al., *Microbiol.* 30, 55-57 (1985). However, there is nothing in the prior art disclosing the use of enzymes in combination with bacteria to produce slow release magnesium-ammonium phosphate fertilizer. The combination of enzymes and bacteria in accordance with this invention accelerates the production of crystalline magnesium ammonium phosphate and increases its yield. The advantages of the present invention over the prior art will be fully appreciated by reading the following description.

II. SUMMARY OF THE INVENTION

[0006] The present invention provides a process for producing slow-release fertilizer from animal manure by composting it with a magnesium-rich compound or a solution of a water-soluble magnesium salt.

[0007] The animal manure is mixed with a magnesium compound or an aqueous solution of magnesium salt. The temperature of this mixture is maintained at 20-30° C. and the pH is maintained between 7-10. Urease is added to the mixture. Next, the mixture is inoculated with bacteria of the species *Bacillus sphaericus*, *Bacillus globisporus*, or *Bacillus fusiformis*. The mixture is then allowed to incubate for about 14 days to form magnesium ammonium phosphate. Optionally, phosphatase, an enzyme promoting the formation of phosphate from phosphorus-rich organic compounds, is added with the urease enzyme to increase the yield of magnesium-ammonium phosphate.

III. DETAILED DESCRIPTION OF THE INVENTION

[0008] Animal manure is mixed with a low water-solubility of magnesium compound or an aqueous solution of a

magnesium salt. Magnesium carbonate, magnesium hydroxide, in the amount of at least 1.7 parts per part of nitrogen in the manure, is added to the animal manure. Highly water-soluble magnesium salts such as magnesium chloride and magnesium sulfate may also be used, but their dosage must be carefully controlled so as to prevent high osmotic pressure of salts which may kill the bacteria. Magnesium sulfate has the additional disadvantage that sulfides or mercaptans may be generated, which have an offensive odor and which may discharge toxic air emissions. Magnesium carbonate and magnesium hydroxide provide alkaline buffering to prevent the magnesium ammonium phosphate from being dissolved after it forms.

[0009] The temperature of this mixture is adjusted to 20-30° C. and maintained in this temperature range. The pH is adjusted to 7-10 by aerating or addition of an acid. Enzymes such as urease are added to the mixture at a dosage of about 0.5 mg of bean sprout urease per liter of mixture. Jack Bean urease Type IX at 62,100 units per gram is suitable. Another suitable material is marketed by Worthington Biochemical Corporation, Lakewood, N.J. The solid enzyme is mixed with 0.1 molar phosphate buffer to bring the enzyme into solution.

[0010] Next, the mixture is inoculated with bacteria of the species *Bacillus sphaericus*, *Bacillus globisporus*, or *Bacillus fusiformis* which are isolated from guano. Commercial guano can also be used. The mixture is allowed to incubate for about 14 days at 25 to 30° C. to form magnesium ammonium phosphate.

[0011] In an alternate embodiment of this invention, a phosphatase enzyme is added to the batch along with the urease. Typically, an alkaline phosphatase such as bovine alkaline phosphatase (Roche Molecular Biochemicals) is used. This enzyme is added at a dosage of 50 ml of bovine alkaline phosphatase at a concentration of 1000 units/microliter to one liter of manure. The enzyme is blended in with the manure immediately after the addition of the urease and before the addition of the bacterial inoculation.

[0012] While there have been shown and described what are considered at present to be the preferred embodiments of the present invention, it will be appreciated by those skilled in the art that modifications of such embodiments may be made. It is therefore desired that the invention not be limited to these embodiments and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

We claim:

1. A process for producing slow-release fertilizer from animal waste comprising the steps of:

- (a) mixing the animal waste with a water-soluble magnesium salt;
- (b) adjusting the pH of the mixture from (a) to between 7 and 10;
- (c) adding urease enzyme to the mixture resulting from (b);
- (d) inoculating the mixture resulting from (c) with bacteria; and

(e) maintaining the mixture resulting from (d) at 25-30° for about 14 days;

whereby magnesium ammonium phosphate is formed.

2. The process in accordance with claim (1) wherein the water-soluble magnesium is selected from the group consisting of magnesium carbonate and magnesium acetate.

3. The process in accordance with claim (1) wherein the mixture resulting from step (c) is inoculated with bacteria selected from the group consisting of the group consisting of *Bacillus sphaericus*, *Bacillus globisporus*, and *Bacillus fusiformis*.

4. The process in accordance with claim (1) further comprising the step of adding a phosphatase enzyme to the mixture.

5. The process in accordance with claim (1) further comprising the step of adding a urease enzyme to the mixture.

6. The process in accordance with claim (1) wherein the adjustment of pH in step (b) is accomplished by aeration of the mixture resulting from step (a).

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