Morphological Variation Among Magnesium Phosphates Recovered from Wastewater

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Introduction

▪Phosphorus (P) in agricultural, industrial, and municipal wastewater can contribute to eutrophication of surface water bodies through over-application or discharge.

▪Magnesium (Mg) phosphates can form spontaneously in wastewater, or can be forced to precipitate as part of treatment.

▪Forced precipitation of Mg phosphates such as struvite ($MgNH_4PO_4 \bullet 6H_2O$) can be used to reduce risks to surface water quality while creating a useful product.

▪There is evidence that recovered Mg phosphates are effective fertilizers in acid soils (Li and Zhao, 2003).

Methods

- X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy dispersive spectroscopy (EDS) were used to examine 4 recovered Mg phosphates:
  1. Material recovered from a food processing plant during cleaning (**"Dittmarite"**)
  2. Crystalline struvite manufactured at a dairy in Washington using a cone-shaped fluidized-bed reactor (Bowers et al., 2007; Bowers and Westerman, 2005) (**"WA Struvite"**)
  3. Material made at a Colorado dairy using the same process as 2, above (**"CO Conventional"**)
  4. Material made at a Colorado dairy using a modified process (Massey et al., 2007) (**"CO New"**)
- Particles were affixed to aluminum cylinders for examination of their three-dimensional characteristics.
- Particles were also encased in epoxy and ground to enable detailed SEM-EDS examination of their interior.

Results

▪XRD identified crystalline struvite in the WA Struvite sample, and identified the unknown sample of crystalline Dittmarite.

▪XRD analysis found no crystalline struvite in the CO Conventional or CO New samples, even though P and Mg were removed from the wastewater by the reactor.

▪Examination of the various types of recovered material using SEM-EDS found particles having a 1:1 ratio of Mg:P in all samples.

▪There were considerable differences in the nature of the particles where Mg phosphates were found.

- ▪WA Struvite had regular structure **(Fig. 1)** and crystalline struvite on the surface of Ca phosphate seed material **(Fig. 2)**.
- ▪Mg phosphate and sand were found in the Dittmarite sample **(Fig. 3&4)**.
- ▪Amorphous and semi-crystalline features **(Fig. 5)** were found in the CO Conventional and CO New material, along with Mg phosphate surface precipitates on the Ca phosphate seed material **(Fig. 6&7)**.

Crystalline Struvite ($MgNH_4PO_4 \bullet 6H_2O$)

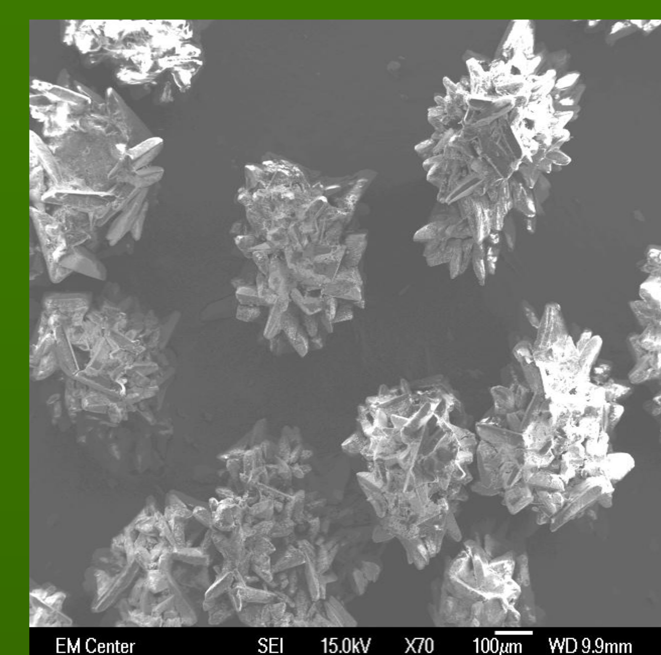
Figure 1a

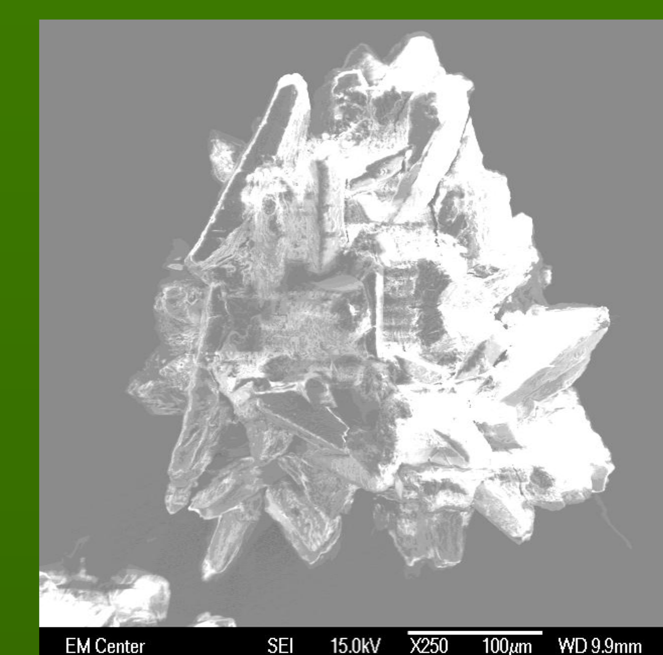
Figure 1b


Figure 2a


Figure 2b

KEY: Mg P crystals, Ca P seed material (magenta), Silicates (blue)

Crystalline Dittmarite ($MgNH_4PO_4 \bullet H_2O$)

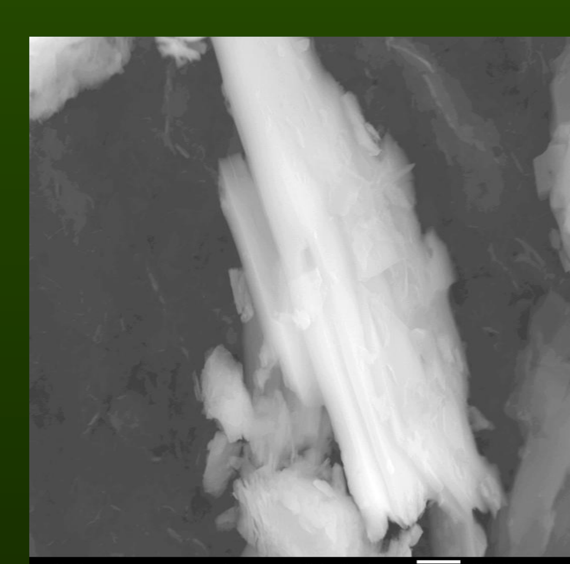
Figure 3a

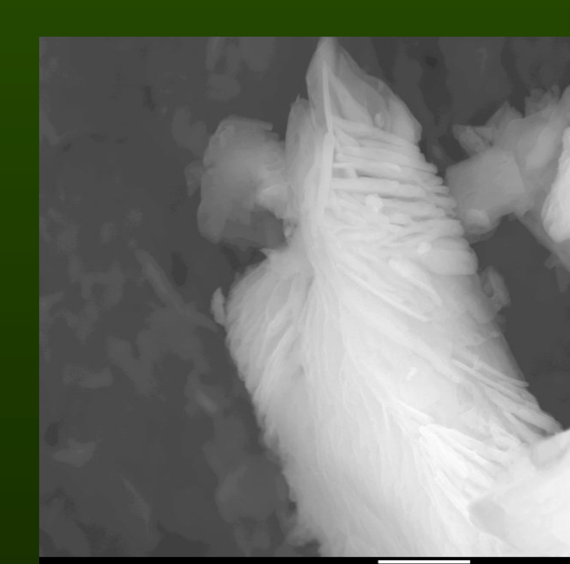
Figure 3b

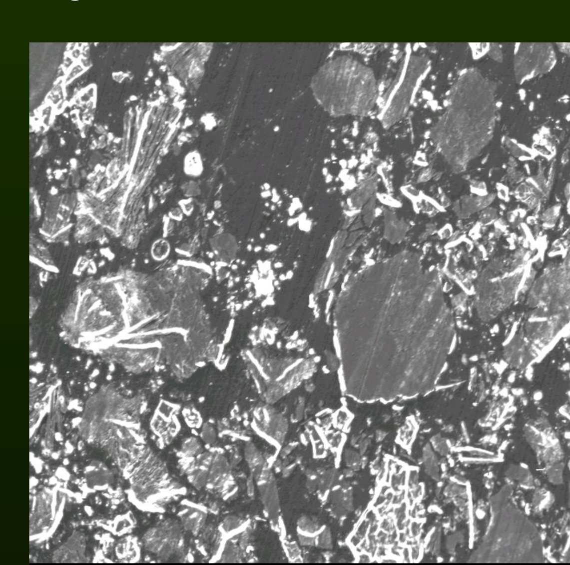
Figure 4a

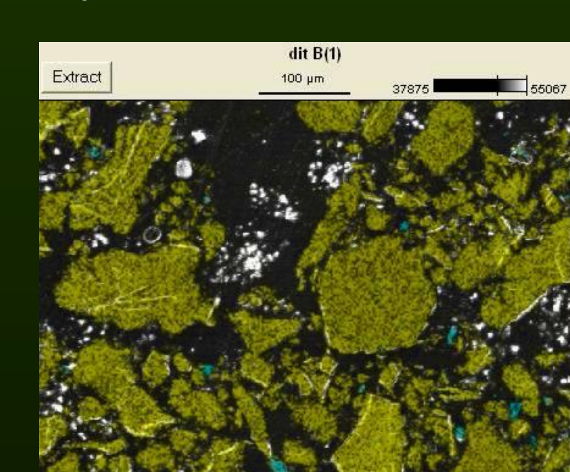
Figure 4b

Non-crystalline Mg Phosphates

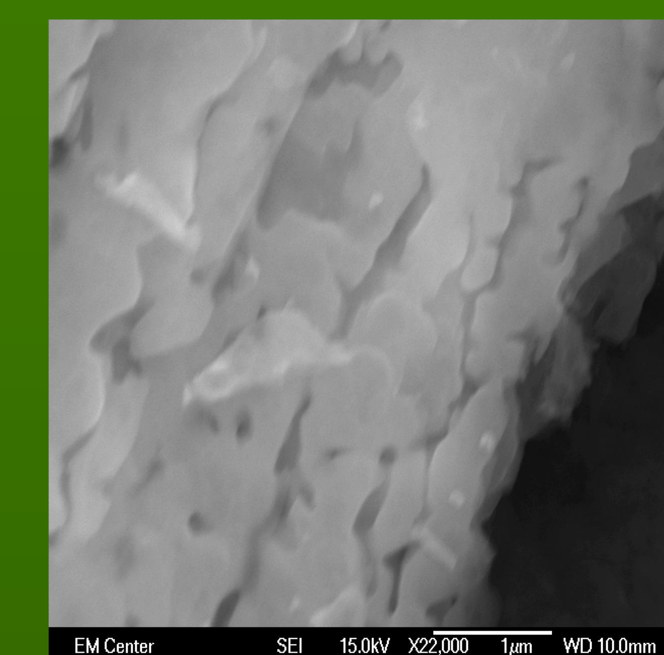
Figure 5

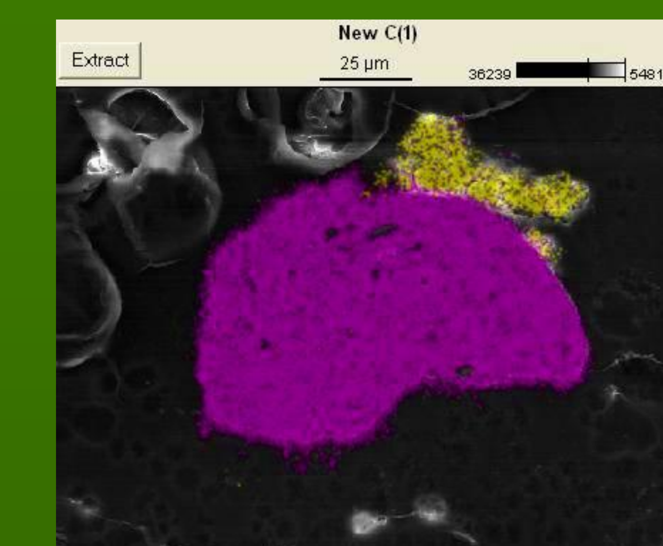
Figure 6

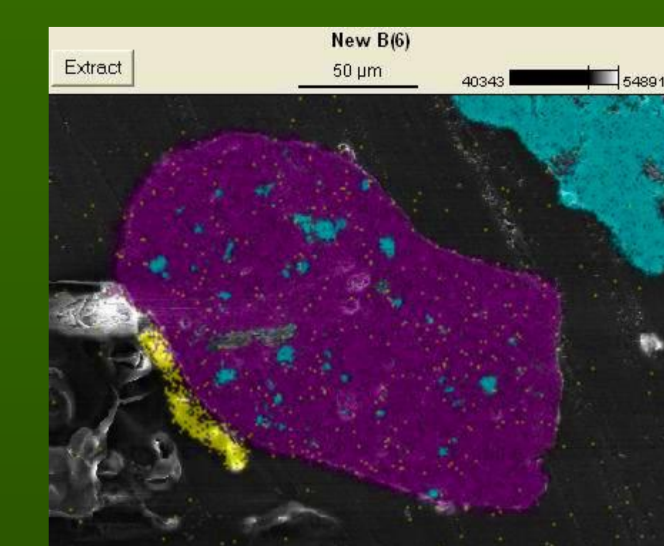
Figure 7a

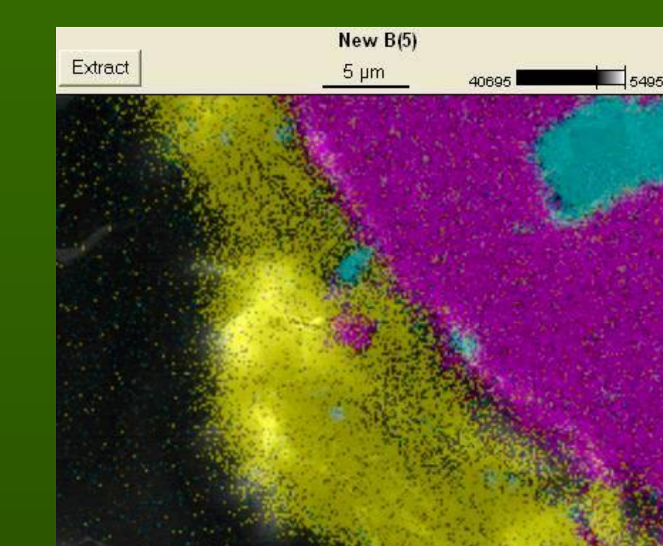
Figure 7b

Discussion

▪The recovered Mg phosphates examined in this study have varying structure, from crystalline to semi-crystalline/amorphous. Other recent studies (Le Corre, 2007; Huang et al., 2006) have examined crystalline struvite showing still different morphological characteristics from those in this study.

▪This highly variable nature could have an effect on the usefulness of recovered Mg phosphates due to inconsistent chemical composition or altered solubility characteristics.

▪Successful P and Mg removal in struvite crystallization reactors does not necessarily result in a uniform or crystalline product.

- ▪Process modifications such as a larger reactor, a slower flow rate, or influent pretreatment might lead to a more consistent product.

▪The products from new Mg phosphate recovery processes can be examined microscopically to elucidate the details of reactor performance and product characteristics.

Conclusion

Examination of various recovered Mg phosphates using X-ray diffraction (XRD), scanning electron microscopy (SEM) and electron dispersive spectroscopy (EDS) showed extensive differences in the nature of the recovered materials.

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