Minnesota Technical Assistance Program

POLLUTION PREVENTION THROUGH CHEMICAL SUBSTITUTION

Overview

Food manufacturers ensure consistent food safety and quality, making thorough cleaning and disinfection essential to meet these standards. In the food manufacturing industry, clean-in-place (CIP) is a process where acid and caustic sanitization cycles remove food residue, scale, bacteria, and other contaminants from the interiors of equipment and piping. However, certain acids contain elements or ions that can be difficult for conventional wastewater treatment facilities to remove.

Sanitization Chemicals

Nitric acid is widely used because it is affordable, broadly available, and generally effective for sanitation. In certain applications where nitric acid may be inadequate, phosphoric acid or a blend of nitric and phosphoric acid can serve as alternatives. Both acids react with caustic sanitizers, such as reacting with sodium hydroxide to form salts (nitrates and phosphates respectively), that may remain in treated effluent. Phosphate treatment typically involves chemicals, such as alum ($Al_2(SO_4)_3$) or ferric chloride ($FeCl_3$), which can contribute to elevated concentrations of sulfates and chlorides in the receiving waters. In addition, excessive acid use can cause low-pH wastewater to be discharged to municipal sewer lines and treatment facilities, which can be harmful to wastewater discharge.

Sanitization Chemicals

- Nitric acid (HNO_3)
- Sulfuric acid (H_2SO_4)
- Phosphoric acid (H_3PO_4)
- Acetic acid ($HC_2H_3O_2$)
- Peractic/peroxyacetic acid (HCH_3CO_3)

Best Practices for Chemical Substitution

Replace Phosphoric Acid with Nitric Acid

Following a recommendation from the local municipal wastewater treatment plant, MnTAP staff members conducted a site visit at a meat processing facility to assess phosphorus use. Based on a review of Tier II data and facility operations,

About MnTAP

The Minnesota Technical Assistance Program (MnTAP) is a confidential, no-cost, and non-regulatory program at the University of Minnesota that provides technical assistance focused on pollution prevention to organizations in Minnesota.

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MINNESOTA POLLUTION CONTROL AGENCY

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Annual Pollution Prevention:
150 lbs. Phosphorus

Cost savings:
$0

Status:
Proposed

MnTAP found that a phosphoric-nitric acid blend used for equipment sanitization is a likely source for phosphorus loading in wastewater. MnTAP advised the facility to work with their chemical representative and quality assurance personnel to replace the current blend with a sanitizer containing only nitric acid.

Following this recommendation could lead to the facility saving 150 pounds of phosphorus annually. While switching to the new sanitizer may offer minimal cost savings, it could reduce the phosphorus load in wastewater and help avoid future surcharges. All chemicals considered for introduction at the facility should be carefully reviewed and selected to ensure they do not increase phosphorus loading to wastewater.

Use Acid Blends with Lower Proportions of Phosphoric Acid

Annual Pollution Prevention:
590 lbs. Phosphorus Loading
7,700 lbs. Ferric Chloride

Cost savings:
$6,600

Status:
Proposed

While some food manufacturers may require phosphoric acid for certain applications, it may be possible to reduce the amount of phosphoric acid in a sanitizing chemical. At another food processor, MnTAP staff members observed two different phosphoric-nitric acid blends being used as equipment cleaners. Based on their safety data sheets (SDS), one blend's phosphoric acid concentration is over six times greater than that of the other blend. Factoring in the facility throughput, switching to a lower phosphoric acid blend could reduce phosphorus loading in wastewater by 590 pounds, ferric chloride by 7,700 pounds, and save $6,600 in ferric chloride solution costs annually.

Use Acid Blends without Nitric or Phosphoric Acid

Annual Pollution Prevention:
800 lbs. Phosphorus Discharge

Cost savings:
$1,000

Status:
Proposed

A dairy processor reached out to MnTAP on how to reduce strength changes resulting from phosphorus loading in excess of their permitted threshold. MnTAP staff members identified two potential sources of phosphorus: one sanitizer with phosphoric acid that is used for internal sanitization (CIP) and another sanitizer with phosphoric acid used for external cleaning. Based on facility throughput and regular operations, replacing these sanitizers with non-phosphorus containing alternatives could reduce phosphorus discharge by 800 pounds and save approximately $1,000 in strength charges annually.

Due to product restrictions on nitrate content, nitric acid is not a viable replacement for these sanitizers. The facility may consider using peracetic or citric acid-based chemicals for sanitization instead of those containing phosphoric or nitric acids. Many chemical suppliers offer non-phosphoric and non-nitric alternatives. Given that phosphoric and nitric acids are often the least expensive acid options for sanitization, alternatives will likely cost more. These alternatives could be more economical, depending on how acid prices and availability fluctuate.

Conclusion

Pollution prevention does not have to come at the expense of maintaining facility sanitation. Alternative cleaning agents, which pose less harm to wastewater treatment systems than common acid sanitizers, exist for a vast array of products and/or components that need to be cleaned. Considering how widely used acid sanitizers are, insights from these studies could inform subsequent investigations at other food and beverage manufacturers throughout Minnesota.