Water Environment Federation®
the water quality people®

PHOSPHORUS IN BIOSOLIDS:

How to Protect Water Quality While Advancing Biosolids Use

Phosphorus: A Critical Nutrient with Recent Challenges

The element Phosphorus (P) is a critical nutrient for crop and livestock production due to its role in root growth and seed (grain) development. However, long-term land application of P-rich organic soil amendments (including manure and biosolids in addition to commercial fertilizers) has sped up the natural process of eutrophication, the nutrient enrichment of surface water, resulting in:

- Increased drinking water purification costs
- Reduced fishing and recreational availability
- Reduced aesthetic value

Potential for surface water contamination with P from human-related activities is based on:

- soil P concentration,
- proximity to surface waters, and
- environmental availability of P in soil amendments.

Phosphorus Sources

Mineral phosphate fertilizers are produced by mining phosphate rock, an energy-intensive process that generates radioactive waste. Phosphate reserves are depleting, are only available in limited locations, and are a non-renewable resource.

Biosolids are the nutrient-rich organic materials resulting from the treatment of wastewater treatment residuals, and can be used as a source of fertilizer for feed and fiber crops. Benefits of land-applying biosolids include:

- Recycling of a locally existing product that would otherwise be landfilled
- Reduced biosolids management and disposal costs for municipalities
- Reduced environmental impact and cost of importing mineral P
- Lower cost to farmers than mined P
- Enhancement of soil properties

As with all organic-based fertilizers, biosolids are an "unbalanced" fertilizer, which means applying at the crop's Nitrogen (N) need will result in an over-application of P. In turn, long-term biosolids application at the N rate can increase soil P and the potential for P runoff to surface waters.

Phosphorus Tests

Plant-Available P is the most accurate P test for soil amendments, because it measures the P that is most likely available for uptake by plants. The Water Extractable P (WEP) Test measures the portion of P that is water-soluble and therefore potential risk to water quality.

Studies have demonstrated biosolids have significantly reduced WEP compared to that of mineral fertilizers and animal manures due to relatively high levels of P-binding constituents (i.e. aluminum or iron) found in wastewater solids. Therefore, guidelines that assume runoff and leaching potential of all soil amendments - chemical fertilizers, manures, biosolids, composts - is the same, may result in unwarranted restriction of biosolids application.

"Phosphorus Source Coefficients" (PSCs) account for the differential P-loss potential of soil amendments based on WEP content of the material to be land applied. In states where P indices incorporate lower PSCs for biosolids, land application is a viable alternative.

The P Index is a scoring matrix for the dynamic phosphorus system at a particular site. The P Index incorporates source factors and transport factors to assess P risk. Some states have implemented P-indices with very restrictive P allowances, which limits application of biosolids.

P Regulations

Federal biosolids regulations developed in the early 1990's (40 CFR Part 503) allow land-application of biosolids at the agronomic rate for N, inherently allowing for P application in excess of crop need.

Mounting concerns regarding the adverse effects of excess surface water P have prompted states to implement strict fertilizer laws that reduce or prohibit land application of biosolids products and other P-containing residuals without any regard to the P availability in these products. In many cases, biosolids are not formally defined within these regulations, leading to uncertainty for users and regulatory bodies attempting to interpret and enforce the laws.

To promote the viability of biosolids land-application, it is important that wastewater and biosolids managers:

- Emphasize legal clarification for biosolids with the appropriate state regulatory agencies (especially during public comment periods)
- Urge the integration of P source coefficients in regulations and the state P index
- Note the P testing method required by regulations and emphasize importance of WEP testing
- Educate lawmakers and agricultural advisors (e.g. Cooperate Extension and NRCS staff) about the many benefits of using biosolids to encourage flexibility in fertilizer regulations
- Employ *Best Management Practices* (BMPs) to demonstrate that the biosolids community understands that, when used responsibly, biosolids are a valuable resource

Best Management Practices to Reduce P Losses

When farmers employ the BMPs discussed below, biosolids are not an environmental liability, but are a resource that enhances soil quality.

BMP #1: Implementing a Nutrient Management Plan

A nutrient management plan is designed to optimize nutrient use for crop production and to reduce water quality impacts in a scientifically sound and cost-effective manner. Optimizing biosolids application based on specific crop yield targets helps to minimize P loss through runoff. P management is required for some operations under provisions of the NRCS 590 program.

Assistance in nutrient management planning is available through the land-grant university system and many state departments of agriculture, environment, and/or conservation.

BMP #2: Match application rates with crop P needs

Biosolids generally contain higher P and lower potassium (K) concentrations in relation to the level of nitrogen (N) needed by the crop. The application rate can be optimized by:

- applying to meet the crop's P needs, with supplemental N and K commercial fertilizers; or
- land application on a 3 to 5-year cycle based on the N application rate.

BMP #3: Proper biosolids storage

Proper biosolids storage reduces nutrient runoff. When storing biosolids, it is important to minimize the exposure to precipitation and other sources of water. Any significant precipitation or runoff that comes in contact with stored biosolids may transport contaminants to water resources. BMPs to address this issue include:

- proper shaping of field stockpiles to shed water and avoid puddles of water,
- construction of enclosed storage facilities or lagoons/pads with impervious earthen, concrete, or geotextile liners,
- providing buffers between storage areas and waterways.

BMP #4: Minimize erosion/surface losses

P is tightly adsorbed to soil particles. The primary mode of P transportation is via erosion and sediment movement from the soil surface. Employing farming practices that will minimize soil loss on agricultural fields where biosolids are applied is critical for reduced P movement into waterways. BMPs to reduce soil and biosolids movement include:

- reduced or no tillage,
- maximizing plant residue after harvest, and
- planting cover crops.

P can also be transported via stormwater runoff. To minimize this movement, avoid biosolids application:

- immediately preceding precipitation events,
- on snow-covered or frozen ground,
- on steep slopes, in wetlands, or on exposed ledges or areas with shallow bedrock.

BMP #5: Apply other residuals to reduce P solubility

Many drinking water treatment facilities produce residuals that contain aluminum or ferric hydroxide precipitates as part of their water treatment process. Applying water treatment residuals (WTR) with biosolids can increase P adsorption in the soil, thereby reducing its availability without adversely affecting soil fertility and crop yields. WTR can also be applied in field edges and buffer areas close to surface waters, to serve as a barrier against P movement.

BMP #6 (at the source): Remove P from biosolids at the WRRF

Advanced nutrient harvesting technologies are now available that can remove a large percentage of the P in the treatment process and recover it as a high value concentrated mineral material. For example, there are a more than a dozen facilities already utilizing or constructing struvite recovery process such as Ostara's Pearl® Process and Multiform Harvest's Multiform™ process in North America. As this technology advances, it is likely that more WWRFs will implement P removal as a part of their BMP plans.

Additional Resources

- Phosphorus in Biosolids: How to Protect Water Quality While Advancing Biosolids Use, [full version, 19 pages] WEF RBC Sustainable Residuals Use Subcommittee, May 2014, http://www.wrrfdata.org/PhosphorusFS/WEF-PhosphorusFactSheet2014.html
- Moving Toward Resource Recovery Facilities, WEF, 340 Pages, 2014, ISBN :978-1-57278-303-4
- The Nutrient Roadmap, WEF, 184 pages, 2015, ISBN: 978-1-57278-314-0
- National Biosolids Partnership, WEF, http://biosolids.org
- Natural Resources Conservation Service, USDA, http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/landuse/crops/npm/
- Water Environment Federation, http://www.wef.org
- Enabling the Future: Advancing Resource Recovery from Biosolids, WEF, 2013.
- "Solids Process Design and Management" (Chapter 21: Sidestreams from Solids Treatment Processes), WEF Press, 2012.
- "What every operator should know about biological phosphorus removal." WE&T (Operator Essentials), July 2013, p. 48-50.
- Leaders Innovation Forum for Technology (LIFT), Phosphorus Recovery, WEF/WERF.
- Nitrogen and Phosphorus Pollution Data Access Tool (NPDAT), US EPA.

Acknowledgments, see RBC Sustainable Residuals Use Subcommittee authors and reviewers at http://www.wrrfdata.org/PhosphorusFS/WEF-PhosphorusFactSheet2014.html#page1

CONTACT:

Water Environment Federation
601 Wythe Street Alexandria, VA 22314
703-684-2400
email: biosolids@wef.org