Phosphorus Fertilizer

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Phosphorus (P) is an essential nutrient needed for plant growth, crucial to root development, proper plant maturation, and seed development. Therefore, P is essential to maximize forage and grain production. With an increase in demand for food products and a diminishing amount of arable land, farmers are more reliant on inorganic fertilizers. These external plant nutrients are imperative to support an increasing population. However, excess amounts of phosphorus in the soil can cause water quality deterioration due to runoff and erosion processes. Many types of phosphorus fertilizers are available and proper management is fundamental in order to create a sustainable and environmentally sound farming system and minimize environmental impact.

Manufacture of Common Fertilizers

Rock phosphate is the raw material used to manufacture commercial phosphate fertilizers, many of which are shown in Table 1. Rock phosphate is directly used in some developing countries; however, due to high transportation costs, low soil availability of P (3-8%), and low crop response it is not commonly used in the United States.

Table 1: Common commercial phosphorus fertilizers, percentage of nitrogen, phosphorus, and potassium, and properties for consideration when selecting a fertilizer

Commercial P Fertilizers		N-P-K	Properties
Rock Phosphate		0-20-0	Low solubility; best for home landscape
Triple Super Phosphate	TSP	0-46-0	High Solubility
Di-ammonium Phosphate	DAP	18-46-0	Dissolves to form slightly basic solution
Mono-ammonium Phosphate	MAP	11-52-0	Dissolves to form slightly acidic solution
Ammonium Polyphosphate	APP	10-34-0	Liquid; slightly acidic solution
Superphosphate	OSP	0-20-0	Sulfuric acid and rock phosphate; 10% sulfur

Phosphate rock is either treated with a furnace (dry) or treated with a sulfuric, phosphoric, or nitric acid (wet) to produce phosphoric acid. The dry process is more expensive but produces very pure phosphoric acid. Triple super phosphate (TSP) is produced by the reaction of phosphate rock with phosphoric acid. Anhydrous ammonia is added to the phosphoric acid to produce mono-ammonium phosphate (MAP) and di-ammonium phosphate (DAP). When phosphoric acid is heated, polyphosphate is formed and is used to produce ammonium polyphosphate fertilizers. All processes produce plant available forms of phosphate (orthophosphate) (Rehm et.al, 2002). A schematic of the phosphorus fertilizer manufacturing process is diagramed in Figure 1.

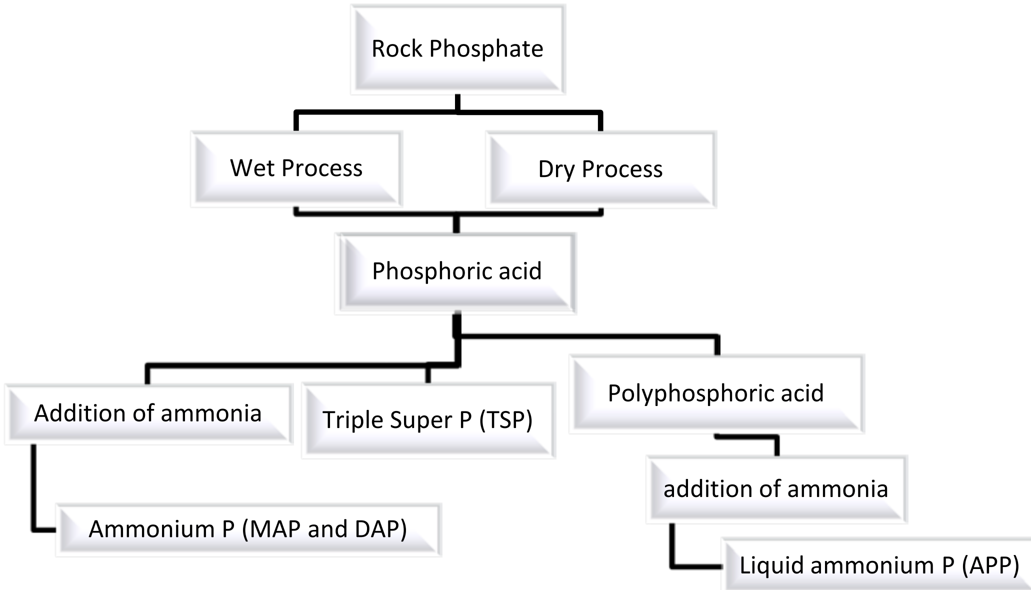

Figure 1: Manufacturing processes of major types of fertilizers and percent of available P

The manufacture of phosphate fertilizer produces fluoride and sulfur dioxide emissions; however, emissions are regulated to meet world health standards. A by-product associated with phosphate production is phosphogypsum which is produced in the wet-process and contains radium making it difficult to discard (Withers et.al, 2005). Many improvements are being made to minimize environmental impact of fertilizer production and utilization. For example, by-products of the phosphate industry are being evaluated for use as soil amendments.

Effect of Phosphorus on Aquatic Ecosystems

When phosphorus builds up in the soil, particulate and water soluble phosphorus are more likely to runoff and enter surface or groundwater and cause eutrophication. Runoff can occur from agricultural land, golf courses, and heavily fertilized residential lawns. Because phosphorus is a limiting factor for algae and aquatic plants in freshwater systems, an influx of the nutrient causes algal blooms as shown in Figure 2. The algae eventually die and are broken down by microorganisms. The microorganisms consume the dissolved oxygen which is necessary for fish populations to survive. Eutrophication also reduces water quality and increases costs for water treatment facilities. Once a body of water is eutrophic, the clean up process is nearly impossible. Therefore, prevention is the best policy.

Figure 2: Example of a eutrophic body of water.
http://www.macalester.edu/environmentalstudies/threerivers/studentprojects/ENVI_133_Spr_08/Phosphorus/Phosphorus%20Effects%20Webpage.html

Environmental Management

Intensively managed farmland, residential, and golf courses that are adjacent to waterways or prone to water runoff should be more carefully managed for P loss. Five methods used to prevent soil phosphorus and other nutrients from entering waterways are listed below.

- Riparian buffers that include native grassland and managed forests can reduce sediment and nutrients from entering streams.
- No-till cropping should be considered to reduce the impact of erosion and runoff to sensitive water systems, while improving soil structure and water retention.
- Regular soil testing is imperative to monitor soil nutrient needs and implement fertilizer recommendations to minimize environmental impact. The Soil, Water, and Forage Analytical Lab at Oklahoma State University offers recommendations to increase nutrient use efficiency based on soil tests.
- Animal manure should be considered as a substitute for inorganic fertilizers. Application of animal manure recycles nutrients and adds organic matter to the soil. Animal manure may reduce pollution caused by the manufacturing processes of inorganic fertilizers. However, repeated applications should be avoided when soil test P (STP) index exceeds 65 since this is an adequate level for plant growth. In Oklahoma, in a non-limiting watershed manure cannot be applied if the STP index is greater than 400. In a limiting watershed the maximum STP index is 300.
- Phytoremediation, the use of plants to remove excess amounts of P, has been shown to reduce STP, however, this process can be slow and forage must be harvested and removed from the site to be effective.

In agriculture production systems and urban environments P is necessary to maintain yield and landscape quality. With proper management the risk of P entering surface water is minimized. Access the following links for additional sources of information on phosphorous management.

Online Sources of Additional Information

www.Soiltesting.okstate.edu
www.NPK.okstate.edu
www.animalwaster.okstate.edu
Ok Fertilizer Laws http://www.oda.state.ok.us/forms/cps/faar.pdf

References:

Withers, P.J.A., Nash, M.D, and Laboski, C.A.M. 2005. Environmental Management of Phosphorus Fertilizers. P 781-827. In L.K. Al-Amoodi (ed.) Phosphorus: Agriculture and the Environment. ASA, CSSA, and SSSA, Madison, WI.

Rehm, G., Schmitt, M., Lamb, J., Randall G., and Busman, L. 2002. Phosphorus in the Agricultural Environment: Understanding Phosphorus Fertilizers. Department of Agriculture, Food, and Environmental Sciences. WW-06288. University of Minnesota.