Milwaukee Metropolitan Sewerage District

Continuing the Tradition of Milorganite®

Milorganite® is probably the most widely recognized commercial product created from biosolids. It has the granular look and feel of other fertilizers and is widely accepted by both the public and professional turf managers for home garden and lawn use. Milorganite® celebrated its 70th anniversary in March 1996. Prior to its introduction, the only fertilizers available to turf grass managers were manures, dried blood, composts, ammonium sulfate, and other products that were either difficult to handle or risky to use on turf. The development of Milorganite® represented a true breakthrough because it was a product that could safely provide long-lasting results and yield high quality turf grass. Its integration into the consumer marketplace has been so successful that many homeowners are unaware of the product's origins.

A Long History

Milorganite® was developed in the early 1920's out of the necessity to clean up the City of Milwaukee's water systems. Until the beginning of the twentieth century, Milwaukee dumped all of its sewage into three rivers; the Milwaukee, Menomonee, and Kinnickinnic rivers, eventually flowing directly to Lake Michigan. Then, as now, all of Milwaukee's drinking water came from Lake Michigan, which also served as a popular recreation resource. In 1913, the Wisconsin state legislature authorized the City of Milwaukee to create a sewerage commission charged with the responsibility of cleaning up the waterways. That same year, a chemist in Birmingham, England, experimenting with sewage sludge allowed air to bubble through the wastewater for a period of time. When the air was turned off, and the mixture settled, the water was purified. This was the beginning of the activated sludge process. The Milwaukee Sewerage Commission studied the new process and formally adopted it for use on December 31, 1919. In 1921, interceptor sewers were connected to municipal sewers to centralize all wastewater treatment. Jones Island, on the shore of Lake Michigan, was chosen as the site for wastewater treatment, and in 1923 construction began on the world's first large scale activated sludge plant at a cost of about $15 million. (In 1974, the Jones Island plant was named a national historic engineering site by the American Society of Civil Engineers because the design of the plant demonstrated such foresight.) The plant was managed under the newly created Milwaukee Metropolitan Sewerage District (MMSD).

Although the purpose of the Jones Island Wastewater Treatment Plant was to produce clean water from wastewater, the MMSD staff was also faced with the significant task of managing the solids emanating from the activated sludge process. To this end, MMSD established a fellowship at the University of Wisconsin's College of Agriculture under the direction of Professor Emil Truog to investigate uses of activated sludge as a fertilizer and awarded Oyvind Juul (O.J.) Noer the grant to carry out the work.

Noer determined that the average nutrient analysis of the biosolids was 6.2 percent total nitrogen with 5.17 percent being water-insoluble nitrogen; 2.36 percent P_2O_5; and 0.4 percent K_2O. In his literature review, Noer discovered that the MMSD material closely resembled "high grade" organic nitrogenous fertilizers, and gave superior growth results compared to manures and chemical fertilizers used at the time. After experimenting with various field crops and vegetables, Noer tested the use of his organic fertilizer product on lawns and found it better and cheaper by one-third than fertilizers commonly being used. Additionally, the MMSD residual product provided two distinct advantages. First, turf did not burn, even with misapplication. Second, the biosolids produced a dark-green, dense turf without causing excessive top growth. Noer then turned his attention to golf courses. Initial test plots at golf courses in Milwaukee and Madison, Wisconsin, yielded excellent results. Plots subsequently were established in Chicago, Detroit, St. Louis, Cleveland, and St. Paul. This new organic fertilizer soon was recognized as a commercially viable product. In 1925, the Sewerage Commission concluded that the water residual disposal problem they faced could be solved by producing and marketing the fertilizer.

Biosolids as a Commercial Product

Milwaukee's next step was to select a marketable name for the product. The city sponsored a contest in National Fertilizer magazine to name the new organic fertilizer. The $250 first prize was awarded to McIver and Son of Charleston, South Carolina, for the name Milorganite®, "derived from MILwaukee ORganic NITrogen." The Sewerage Commission began taking orders in late 1925, and commercial production of Milorganite® began in August 1926. By the end of the year, about 5,500 tons of fertilizer were inventoried with orders for 2,500 tons.

To stimulate sales, the Commission arranged an exhibit at the International Golf Show in Chicago in late March, 1927 and printed 5,000 booklets and 10,000 flyers describing Milorganite®. Golf surged in popularity during the Roaring 20's, and by the end of 1927, 23,555 tons of Milorganite® had been sold. By the mid-1930's, production grew to about 50,000 tons per year - at prices up to $20 per ton - and could not meet demand. Most Milorganite® was sold to fertilizer companies for blending with other N-P-K (Nitrogen-Phosphorus-Potassium) sources. Very little was sold to the specialty fertilizer market.In the mid-1930's, Noer established a soils lab to aid in his research on fertilizers. The lab was the first established exclusively for turf grass, and is used today for free soil analysis service to Milorganite® golf course customers. Noer's experiments pioneered much of the methodology used in modern labs, including sampling depths and techniques and laboratory procedures. Additionally, Noer determined through clipping analysis that the basic ratio in plant tissue was 3:1:2 (N:P:K) instead of the commonly accepted 1:4:2 proportion. From these studies came the basic Milorganite® fertility recommendations still used today. Noer's recommendations still perform well even in the low-fertility programs used in modern turf management regimes.

Over the years, Milorganite® has adapted to market changes. In 1926 most Milorganite® was sold in bulk, but by the mid-1930s it was packaged in 25-, 50-, and 100-pound bags. In 1955, packaging changed to offer 40-and 80-pound bags, in the

1970s in 20-kg bags as the metric movement in the United States peaked, and today it is sold in a distinctive 40-lb bag exclusively for the retail market (Figure 1), 50-lb (23 kg) bags for the professional market, and reusable bulk bags for large area applications such as golf course fairways and roughs. The bulk fertilizer blending market also continues to be important to Milorganite® across the country and Canada.

Prices have also changed over the years. In 1926 Milorganite® cost $14.00 per ton. In the mid-1930s the price increased to $20 per ton, and by 1968 it grew to $52.50 per ton. Nonetheless, increases in the price of Milorganite® generally have stayed behind the rate of inflation.

Today Milorganite® remains very popular with professional landscapers and golf course managers. MMSD sells about 55,000 tons of Milorganite® fertilizer every year. About

Figure 1. Milorganite® is sold in a distinctive bag across the U.S. and Canada.

70 percent of the annual production is bagged, and about 30 percent is sold in bulk. About 700,000 50-lb (23 kg) bags are sold to golf course managers and other lawn care professionals. Another 900,000 40-lb (18 kg) bags are sold every year through retail hardware or lawn and garden stores. Bag sales are expected to increase as

Milorganite® withdraws from the bulk market.

An Innovative Treatment Process

MMSD operates two regional treatment plants, Jones Island and South Shore, which are connected by a pipeline transporting South Shore biosolids to the Jones Island Drying & Dewatering (D&D) Facility, where the material is processed into Milorganite®. Filter presses reduce water content in the sludge before the solid "cake" enters massive dryers. The production process allows MMSD to control drying time, temperature and granular "bead" quality. Milorganite® drying time exceeds 30 min, with a temperature gradient of 840 to 1200°F (450 to 650 C) at the dryer inlet, and 180 to 210°F (82 to 100 C) at the dryer outlet. This ensures that biosolids temperatures exceed 180°F (82 C) for at least 30 minutes, with the bulk of the material above 180°F for 60 minutes or more. MMSD's heat drying process surpasses the time and temperature for pathogen reduction required under 40 CFR 503.32.

Heat drying is the most effective method of inactivating viruses and bacterial pathogens in biosolids because viruses are unable to structurally survive temperatures above 180°F (82 C) for any extended period of time. The dry heated material eliminates evaporative cooling at the center of particles, ensuring destruction of all viruses. Lacking protective moisture amidst dryer exit temperatures of 180 to 200°F (82 to 93 C), viruses are destroyed. The heat kills or denatures *Salmonella* bacteria, enteric viruses, viable helminth ova and other pathogens to a level that is, for all practical purposes, pathogen and indicator organism-free. Milorganite® fecal coliform tests consistently show the density to be less than the 2.0 MPN /gram detection limit. If any pathogens remain after heat treatment, they are below detectable levels.
Further, in 14 tests conducted from 1988 to 1993, there was no evidence of *Salmonella* growth of any kind, indicating that the *Salmonella* bacteria do not survive the heat-drying production process. As Part 503 allows certification for pathogen reduction based on fecal coliform alone, Milorganite® is no longer tested for *Salmonella* bacteria.

Milorganite® is shipped a few miles by rail from the Jones Island Treatment Plant to a Milwaukee contractor for bagging. The contractor maintains on-site bulk storage capacity to keep the bagging operation adequately supplied with fertilizer. Shipping to all distributors takes place directly from the bagging operation. Distributors keep Milorganite® in inventory to assure prompt, fresh delivery to retailers. Most distributors place orders in the fall for the next season, typically spring, when consumers make fertilizer purchases for the summer. Bulk (nonpackaged) deliveries of Milorganite® are shipped directly by rail or truck from the D&D Facility at Jones Island.

Environmental Impacts

Milorganite® poses no threat of contamination to aquifers or groundwater. All field studies show that heat-dried, slow-release biosolids have less NO_3 leaching than other alternative fertilizers. Highly insoluble, slow release biosolids such as Milorganite® provide excellent protection from product leaching into the groundwater and from surface water runoff. The metals levels in Milorganite® have declined substantially as a result of industrial pretreatment enforcement. In 1981, the MMSD Commission ordered industries to reduce the amount of cadmium and other heavy metals discharged to the sewer system in their wastewater. As the pretreatment program was phased in over the next decade, levels of heavy metals in Milorganite® dropped significantly (Figure 2). Today Milorganite® samples show consistently low levels of common metals (Table 1). The MMSD lab tests daily, weekly, and monthly composite samples of Milorganite®. Daily sampling advises the plant managers of an unusual elevation in a single metal and the need for immediate system monitoring to investigate and identify the source.

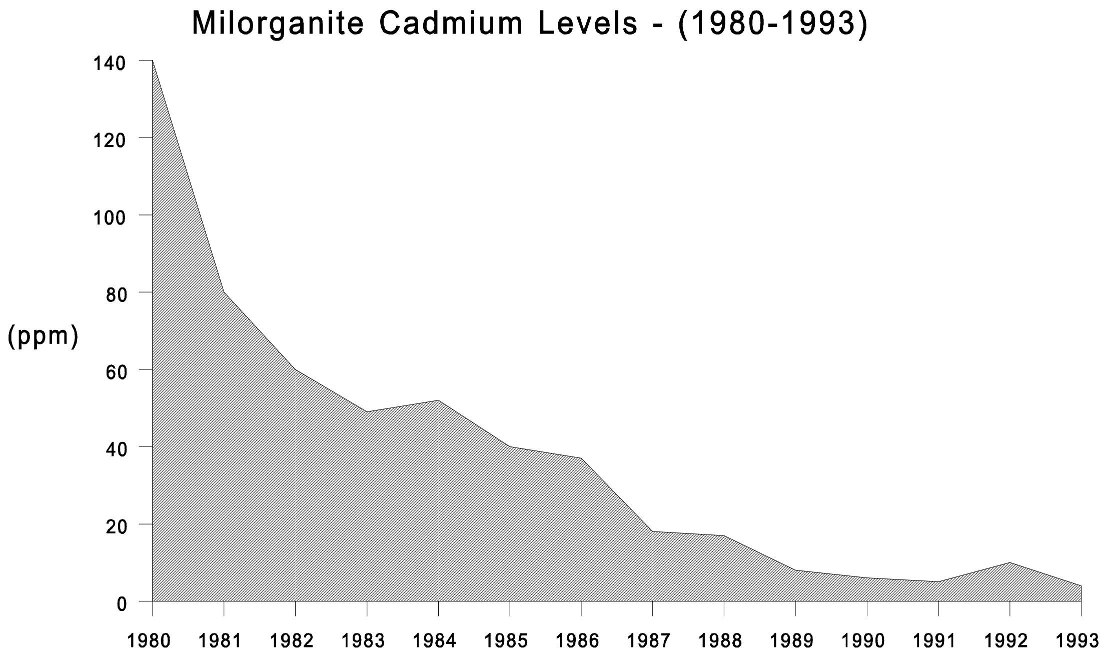

Figure 2. Cadmium levels have dropped dramatically because of pretreatment programs

Cost Benefits

The entire Milorganite national distribution and sales enterprise is worth about $30 million annually. MMSD realizes only a small share of these revenues, about $5 million yearly, which helps to offset solids management costs and to reduce user charges. A 1997 Wisconsin state audit of MMSD determined that producing Milorganite® is the most cost-effective method of biosolids management available to Milwaukee, indicating that landfilling the biosolids would cost at least 40 percent more than making Milorganite®.

Sound, practical agronomic research continues to be a top priority for the MMSD staff today, just as it was for Noer. Milorganite® has been the subject of and has helped fund important research projects at universities nationwide, especially in environmentally sensitive areas such as nutrient leaching and run-off, disease suppression characteristics of organic fertilizer products, and effects of different fertility regimes and sources on irrigation requirements. Today, Milorganite® is marketed and used for turf-building and landscape maintenance applications, such as retail lawn and garden, professional landscaping, grounds, golf course and sports field maintenance. The product remains very popular with professional landscapers and golf course managers.

Table 1. Milorganite samples show consistently low metals concentrations.

Pollutant	EPA Pollutant Limit Concentrations for Exceptional Quality Biosolids Use [503.13(b)(3)] (mg/kg) Monthly Average	1995 Milorganite® Monthly Composite Samples Dry Weight Basis	
		1995 Annual Average (mg/kg)	1995 Minimum& Maximum Monthly Averages (mg/kg)
Arsenic	41	2.14	0.3-6.3
Cadmium	39	3.08	2.10-10.00
Chromium	None	395.2	250-660
Copper	1,500	240.2	190-280
Lead	300	91.7	51-180
Mercury	17	0.98	0.45-2.50
Molybdenum	n/a	7.10	3.0-16.0
Nickel	420	32.6	16.0-50.0
Selenium	100	2.6	0.29-8.5
Zinc	2,800	465.5	310-640