mechanism of nitrogen release depends on both microbial activity and hydrolysis. Its rate of nitrogen release, therefore, is faster than for UF products, but its fertilization effects on turf are of short duration.

Another flowable UF source is *FLUF.* This source contains 18% nitrogen, 20% to 25% of which is water-insoluble. The initial response of FLUF is generally slower than that of urea. FLUF also has a lower potential for foliar burning than urea.

Other Slow-Release Sources. Other slow-release nitrogen sources being developed include Oxamide, Triazines, and Triazones. Oxamide is a diamine of oxalic acid used in Japan for rice production. A double urea product containing approximately 31% nitrogen, it is approximately twice as soluble as IBDU. The release rate is directly related to particle size, hardness, and amount of water present. Following dissolution, hydrolysis occurs primarily by microbial cleavage of the carbon bonds in the presence of the enzyme *amidase,* resulting in the formation of ammonium carbonate. Powdered and fine particles of oxamide nitrify faster than ammonium sulfate and at a rate similar to that of urea in acid soils. Their residual effects, however, are not as lasting as those of particles with coarser grades. When used on turf, oxamide imparts a dark bluish green color. Currently, it is prohibitively expensive.

A pure form of triazine that contains 66% nitrogen is the commercial product *Melamine.* Commercial formulations usually consist of a mixture of triazine and urea containing 40%, 50%, and 60% nitrogen. Nitrogen release depends on microbial activity and is generally slow, since the product contains double carbon bonds that are difficult to cleave (break). Response to Melamine may not occur for 4 to 6 months. A soluble nitrogen source, such as urea, should be used initially with Melamine to provide initial color and to encourage breakdown of the product.

Triazones are similar to triazines except that their ring structure does not contain double bonds. Triazones, which contain approximately 40% nitrogen, can be formulated in a water-soluble form. Nitrogen release is governed by microbial action.

Natural Organic Nitrogen Sources

Natural organic nitrogen sources usually contain various amounts of either composted material or human or animal waste products. Manure, sludges, bone meal, humates, and composted plant residues are traditionally used natural organic nitrogen sources (Table 11). The advantages of using these sources include a low burn potential due to low water-insoluble nitrogen content, limited effect on pH, and low rate of loss from leaching. Other advantages are the variety of nutrients these sources offer in addition to nitrogen, and the potential for improving the physical condition of soils, especially sandy ones. Also, depending on local supply, natural organic nitrogen sources may be available at competitive prices.

Some factors to consider before using these traditional sources include their low rate of nitrogen release during cool weather, a result of their limited microbial activity and low nitrogen content. Owing to this low rate of release, large amounts of material will have to be applied. Other considerations include the fact that natural organic nitrogen sources are more costly per pound of nutrient than soluble sources and the possibility that they will be difficult to store and to apply uniformly. This is true especially when the turf is already established. Some natural organic sources produce an objectional odor after application and contain undesirable salts, heavy metals, and weed seeds. In general, natural organic sources such as manures and composted crop residues should not be used on golf greens because of their potential to hinder soil drainage when large amounts of material are applied.