Using Portable XRF to Facilitate Nutrient Management Planning

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The world-wide demand for inexpensive animal food products including pork, poultry, beef, and dairy, has pushed the industry away from small, mixed cropping and livestock operations to large-scale, confined animal production systems where animal feed is imported. Two important consequences of this are 1) animal wastes are concentrated in space and time, and 2) plant essential elements are not returned to the soils where the feed was produced. Concentrated animal wastes are a potential water quality and human health hazard. In an attempt to remedy these problems, the USDA Natural Resources Conservation Service (NRCS) implemented Comprehensive Nutrient Management Plans (CNMPs) as way to track and manage nutrients on the farm to make better use of the available nutrients and prevent water quality impairments. A CNMP is a set of conservation and management practices that requires analyzing feed, forage, manure, and soil. This is a sample-intensive process that is typically realized in commercial analytical laboratories with wet chemical methods. Our long-term goal is to use field-portable instruments to obtain the necessary data in real time. The initial objectives were to 1) determine the mineral (P, Ca, K, and Fe) content of ground forage samples, specifically the effect of particle size, and 2) determine the mineral content (P, Ca, K, Fe, and Mg,) of dried manure and to quantitatively account for manure moisture content. For objective one, 42 hay samples were oven dried and ground into three particle sizes (≤0.5 mm, 0.25-0.5 mm and 1-2 mm). Prepared samples were placed in cups over thin prolene X-ray film and scanned by PXRF (Bruker Tracer III) using a vacuum (<10 torr) without a filter for 180 seconds. Predictive relationships between PXRF and wet chemical methods were good ($r^2 \geq 0.70$) for all elements and decreased with increasing particle size ($r^2 \geq 0.57$). These results are promising especially because hay is a heterogeneous mixture of species (grasses, legumes, and forbs) and of plant parts (stems, leaves, and seeds). For objective 2, forty animal manure samples (35 beef/dairy and five poultry) were oven dried, ground to <0.5 mm, and brought to four moisture ranges (10-20%, 20-30%, 40-50%, and 60-70%) and scanned as described above. Using a random forest regression technique to account for moisture content, r^2 values between PXRF and wet-chemical methods increased from less than 0.1 to greater than 0.96 for P, K, Ca, Mg, and Fe. Taken together these results indicated that, with additional work, elemental concentrations may be accurately determined in both dried and moist samples using PXRF and expands the potential applications of PXRF for *in situ* elemental determinations for agricultural and environmental samples.