Total Acid Digestion vs. Mehlich-3 Extraction of Poultry Litter Nutrients

Comparison of laboratory results reported in pounds of nutrient per ton of litter.

Background

Poultry litter (and similar manures/composts) is routinely analyzed by strong-acid digestion (typically nitric + hydrochloric acid, analogous to EPA 3050B or aqua-regia methods) to determine total nutrient content. These totals are the basis for nutrient management plans, application-rate calculations, and first-year availability estimates. Mehlich-3 (M3) is a dilute multi-element soil extractant (0.2 M acetic acid + 0.25 M NH_4NO_3 + 0.015 M NH_4F + 0.013 M HNO_3 + 0.001 M EDTA, pH ≈ 2.5) designed to estimate plant-available nutrients in mineral soils, not to dissolve the entire sample matrix.

Paired Laboratory Results

Values are pounds per ton. M3 recovery is calculated as (Mehlich-3 ÷ total acid digest) × 100.

Nutrient	Total (acid digest)	Mehlich-3	M3 as % of total
Total N	53.4	N/R	—
P_2O_5	52.6	4.6	8.7%
K_2O	63	23.9	38%
Mg	7.4	4	54%
Ca	44	4	9%
S	7.8	4	51%
B	0.2	0.18	90%
Zn	0.4	0.026	6.5%
Mn	0.6	0.22	37%
Fe	3.2	0.22	6.9%
Cu	0.8	0.5	63%
Al	1.8	N/R	—
Na	6.4	4	63%

Key Observations

- Highly soluble or exchangeable ions (K, Mg, S, B, Cu, Na) show moderate-to-high recovery.
- Phosphorus, calcium, zinc, and iron recoveries are very low. Poultry litter P exists largely as calcium phosphates and phytate; these forms are only sparingly soluble in the dilute M3 reagent. The same is true for Fe- and Al-associated P and for many micronutrient oxides/organic complexes.
- Nitrogen is not reported by M3 because the extractant is not a total-N digestion.

Pitfalls of Applying Soil Extractants to Litter or Compost

Soil-test extractants such as M3 were calibrated on mineral soils that contain sorption sites, a buffered pH, and far lower total nutrient concentrations. When the same reagent is used on a high-organic-matter, high-P, high-Ca matrix:

- Extractant buffering capacity and ligand (fluoride, EDTA) concentrations can be exhausted, producing incomplete or non-reproducible extraction.
- M3 dissolves a mixture of immediately soluble inorganic P plus a variable fraction of organic P (including phytate), but the recovered amount is not equivalent to either total P or first-year plant-available P.
- Routine soil tests (Bray, Olsen, Mehlich-3, DTPA) are explicitly not recommended for high-organic-matter substrates such as compost or manure; they do not represent the chemistry that occurs after the material is incorporated into soil.
- Using M3 values in place of totals will understate nutrient loading, especially for P, and can lead to incorrect application rates or environmental-risk assessments. Conversely, treating M3 numbers as “available” without soil-specific calibration over- or under-estimates first-year release.
- Extractability of metals from livestock manures is highly dependent on both the waste type and the extractant chosen; no single soil extractant reliably predicts plant availability or environmental mobility from the raw material.

Standard manure-analysis protocols therefore specify acid digestion (or dry ashing followed by acid dissolution) for total elemental content. M3 (or similar soil extractants) may be useful in research settings to characterize acid-soluble fractions of already-applied litter, but they are not a substitute for a total analysis of the amendment itself.

References

Wilson, M.L., et al. (eds.). 2022. Recommended Methods of Manure Analysis, 2nd ed. University of Minnesota Libraries Publishing.

Sullivan, D.M., Bary, A.I., Miller, R., and Brewer, L. 2018. Interpreting compost analyses. Oregon State University Extension EM 9217.

Cade-Menun, B.J., et al. 2018. Characterizing the phosphorus forms extracted from soil by the Mehlich III soil test. Chemical and Biological Technologies in Agriculture 5:7.

Investigation of heavy metals using various extraction methods in livestock manures. Communications in Soil Science and Plant Analysis 43(21).