



Mine land Forage Quality Framework / Protocol

The Mine land Forage Quality Framework provides a science-based protocol for evaluating, monitoring, and managing forage quality on rehabilitated mined land to support sustainable livestock grazing, ecological restoration, and long-term agricultural productivity. Developed in alignment with the AF4RICA Lab Protocols and the African Forage and Pasture Quality Evaluation Programme & Database (FPLRI), the framework promotes regenerative integrated crop–livestock systems on post-mining landscapes.

Key Objectives

- Support sustainable grazing management on rehabilitated mine land.
- Improve soil health, nutrient cycling, and carbon sequestration.
- Ensure nutritionally adequate forage production for livestock.
- Monitor environmental safety through trace metal and CoPC screening.
- Provide traceable, standardised forage quality data for decision-making.

Framework Components

Forage Quality Evaluation

The framework standardises forage sampling, preparation, and laboratory analysis to ensure consistent and comparable results across rehabilitated landscapes.

Core evaluation parameters include:

- Crude Protein (CP)
- Acid Detergent Fibre (ADF)
- Neutral Detergent Fibre (NDF)
- Lignin
- Energy content
- Mineral composition (Ca, P, Mg, K, Na, etc.)
- Constituents of Potential Concern (CoPCs)

It is proposed that forage analysis should align to **AF₄RICA Lab's** integrated Forage Quality Evaluation Protocol, which standardises procedures across the FPLRI - African Forage and Pasture Quality Evaluation Programme and Database.

Each sample must include metadata on:

- (i) *Site age and rehabilitation class*
- (ii) *Species composition*
- (iii) *Grazing regime*
- (iv) *Sampling season (Hot-Wet / Cold-Dry)*
- (v) *GPS coordinates and soil reference ID (for traceability)*

Sample collection and preparation

- (i) *Collect composite samples from quadrats (1 m² each) per site, calculated from and representative of the dominant forage canopy.*
- (ii) *Oven-dry at 55–60°C for 48 hours to constant weight.*
- (iii) *Mill samples to 1 mm using a Wiley Mill before analysis.*
- (iv) *Label and store samples in airtight containers prior to analysis to prevent moisture contamination.*

Monitoring Indicators

AF₄RICA Lab / FPLRI recommends quarterly monitoring of:

- (i) Forage CP, NDF, ADF, P, Ca
- (ii) Soil %C
- (iii) CoPC (Cd, Ni, Pb, Cr, Zn)

Analytical methods

A. Wet chemistry analysis (Benchmark calibration)

Used for baseline and calibration purposes:

- (i) *Crude Protein (CP): Dumas nitrogen*
- (ii) *ADF and NDF: Van Soest detergent system*
- (iii) *Lignin: Acid detergent lignin (ADL) method*
- (iv) *Ash: Dry ashing at 550°C for 4 hours*
- (v) *Minerals (Ca, P, Mg, K, Na, Fe, Zn, Cu, Mn, Co, Mo): ICP-OES following nitric acid digestion*
- (vi) *CoPC's: ICP-MS or other accredited methods*

AF₄RICA Lab recommends that every 10th NIRS dataset be validated through wet chemistry to ensure calibration accuracy. These data feed directly into the database's central calibration model for Southern African grass and legume species.

B. Near Infrared Spectroscopy (NIRS)

NIRS is the preferred method for *routine, high-throughput* forage analysis:

- (i) *Instrument: Perten DA 7250 (or equivalent, 700–2500 nm range)*
- (ii) *Calibration: **AF₄RICA Lab** Master Calibration File (Version 2025.1)*
- (iii) *Parameters predicted: CP, ADF, NDF, lignin, ash, fat, moisture, energy, Ca, P*
- (iv) *Accuracy requirement: $R^2 \geq 0.90$; SEP $\leq 5\%$*
- (v) *Reference linkage: Results uploaded to database for inter-lab harmonisation*

NIRS allows near-instantaneous prediction of nutritional parameters, essential for adaptive grazing management and large-scale mine-land monitoring.

C. Constituents of Potential Concern (CoPC) screening

Under **AF₄RICA Lab**'s CoPC Protocol:

- (i) *Evaluate essential and non-essential elements (Na, K, Mg, P, Ca, Cd, Pb, Ni, Cr, Zn, Cu).*
- (ii) *Calculate Accumulation Factors (AF) = [Concentration in plant tissue / Concentration in soil].*
- (iii) *Acceptable threshold: AF < 10 for non-essential elements; AF > 10 for essential nutrients only.*
- (iv) *If AF > 10 for heavy metals or if above NRC limits, for example Cd > 1 mg/kg DM, flag site for detailed risk assessment.*

Rehabilitated pasture samples from the Coaltech study recorded AF < 10 for all toxic metals, confirming environmental safety for livestock grazing.

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