



## Near infrared spectroscopy to predict liquid and solid manure nutrients.

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### Abstract text

The rational use of farmyard manure is a crucial issue for the future of agriculture. Farmyard manure enable substantial savings on chemical fertilizers and improve soil quality by adding organic matter, stimulating biological activity and improving soil structure. To optimize their effectiveness while ensuring that there is no risk to the environment (leaching of nitrogen and/or phosphorus), it is essential that farmers analyze their manures to determine their actual chemical composition. Standard laboratory analysis can be time-consuming and costly. Near infrared spectroscopy (NIRS) is an attractive alternative as it is a fast, non-destructive, reproducible and cost-effective method. However, to develop robust and accurate predictive models, accurate reference and spectral data are required. For a given farmyard manure, the composition can vary enormously depending on animal species, feed type, housing and storage conditions.

For over 10 years now, REQUASUD (network of laboratory in Wallonia, Belgium) has been building a specific database for liquid and solid manure, containing reference analyses of more than 2900 homogenized samples for pH, dry matter (DM), organic matter (OM), total nitrogen (Nt), ammonium (NH<sub>4</sub><sup>+</sup>) and phosphorus (P), potassium (K), sodium (Na), magnesium (Mg), calcium (Ca) and sulfur (S) expressed in their oxide form. These reference values are associated with spectra measured on fresh homogenized samples with a FOSS XDS (FOSS NIRSystems Inc., Denmark), operating in the 400-2500 nm wavelength range, with 2.0 nm spectral resolution.

The performance of the predictive PLS model was evaluated according to the following criteria: The root mean square error of cross-validation (SECV), The standard error of calibration (SEC), the standard deviation (SD), the determination coefficient (R<sup>2</sup> value) and the ratio of prediction to determination = SD/SEC (RPD). The RPD criterion takes into account the variability of the database. It is a useful indicator to compare results obtained using diverse databases, or results in the literature. A good predictive model has a R<sup>2</sup> close to 1, a SEC as small as possible and close to the reproducibility of the reference method (determined by





proficiency tests), and a RPD greater than 2 or 3 depending on the matrix and the authors (Genot *et al.*, 2014).

Comparison were made including or not the visible part of the spectrum in the predictive models. No significant difference was observed between both ways of prediction signifying that the visible part is not especially required for accurate predictions.

Global performance without the visible spectral part (1100-2498 nm) of liquid and solid manure model are shown in table below. N is the number of reference data for each parameter in the database.

	Liquid manure					Solid manure				
	N	SEC	SD	R <sup>2</sup>	RPD	N	SEC	SD	R <sup>2</sup>	RPD
pH	411	0.21	0.34	0.53	1.62	368	0.33	0.56	0.64	1.70
C/N	741	0.98	2.07	0.65	2.11	939	2.04	4.04	0.75	1.98
<b>DM</b>	1807	0.69	2.28	0.79	<b>3.30</b>	1029	2.02	10.11	0.96	<b>5.00</b>
<b>OM</b>	728	0.63	2.05	0.48	<b>3.25</b>	879	1.36	7.31	0.93	<b>5.38</b>
Ash	753	0.36	0.68	0.43	1.89	1034	1.52	3.73	0.83	2.45
<b>Nt</b>	1760	0.43	1.61	0.78	<b>3.74</b>	923	1.21	5.89	0.95	<b>4.87</b>
<b>NH<sub>4</sub></b>	1427	0.27	0.9	0.72	<b>3.33</b>	432	0.52	1.89	0.96	<b>3.59</b>
K <sub>2</sub> O	1786	1.25	1.71	0.46	1.37	913	2.46	4.90	0.84	1.99
<b>P<sub>2</sub>O<sub>5</sub></b>	1704	0.37	0.73	0.55	1.97	901	0.84	3.62	0.90	<b>4.32</b>
MgO	1697	0.48	0.64	0.16	1.33	901	0.46	1.21	0.76	2.50
CaO	1713	0.88	1.17	0.29	1.33	887	0.48	4.77	0.88	1.74
SO <sub>3</sub>	799	0.34	0.42	0.18	1.24	<30	/	/	/	/

The results show very interesting coefficients of determination, particularly for solid manure. The most remarkable results concern the RPDs obtained for DM, OM, Nt, NH<sub>4</sub> (all > 3 for slurry and manure) and P<sub>2</sub>O<sub>5</sub> (for manure). The prediction of P<sub>2</sub>O<sub>5</sub> on solid manure is probably correlated with the prediction of OM, as P is intimately linked to OM in this type of product. Other minerals are not accurately predicted, which is not surprising when using NIR.

These parameters are currently being predicted by NIR as part of routine operations in the reference laboratory of the REQUASUD network, located at the UCLouvain - Centre de Michamps. The predicted results are validated using two mathematical measures: the GH (Global H or Mahalanobis Distance) and the NH (Neighbor Distance). A satisfactory level of confidence is achieved when GH values are less than 3 and NH values are less than 1.

This study demonstrates the ability of NIRS to accurately determine DM, OM, Nt, NH<sub>4</sub> content in farmyard manures, as well as P<sub>2</sub>O<sub>5</sub> only in solid manures at the moment.





## References

Genot, V., Bock, L., Dardenne, P., & Colinet, G. (2014). L'intérêt de la spectroscopie proche infrarouge en analyse de terre (synthèse bibliographique). *Biotechnologie, Agronomie, Société et Environnement*, 18 (2).

