Phosphorus availability in agricultural soil of Wallonia - A modeling approach

F. Cobert[1], O. Pourret[2], M. Renneson[1], G. Colinet[1]

[1]*Université de Liège, Gembloux Agro-Bio Tech.* *Unité Systèmes Sol-Eau, 2 passage des déportés. B-5030 Gembloux.*
[2]*HydrISE, Institut Polytechnique LaSalle Beauvais.* *19 rue Pierre Waguet. F-60026 Beauvais Cedex.*

Introduction:

During many years, ordinary pratices of P fertilization have led to an accumulation of P in agricultural soils of Wallonia. It has resulted from continuous and excessive fertilization and manure applications (Ranatunga et al., 2013 ; Ju et al., 2007). Thus, a better understanding of P behavior in wallon soils is needed to adapt pratices of P fertilization to the requirement of reducing agricultural impact on the environment (eutrophication of surface waters ; Sharpley et al., 2005, 1994 ; Tunney et al., 1997) without impairing crop yields. Historically, P availability in soil has been studied by a chemical extraction approach. However, this approach is disputed (Shang et al., 2013). Indeed, P available (PO_4-P) mesured in soil by chemical extraction is affected by the P form (organic or inorganic) and P mineral type (Leytem et al., 2002 ; Shang et al., 2013).

In that context we studied PO_4-P in different agricultural soils of wallonia by a modeling approach with the USGS software PHREEQC (Parkhurst and Appelo, 1999) in order to (1) compare soil $(PO_4\text{-}P)_{Observed}$ by the Lakanen-Erviö chemical extraction method (Lakanen and Erviö, 1971) with soil $(PO_4\text{-}P)_{Modeling}$ by PHREEQC ; (2) define soil chemical parameters which influence the P behavior in soils.

Material and methods:

Soil used were collected as part of multi purpose project designed to characterize the soil parent materials (PMs) in Wallonia (Renneson et al., 2013 ; Legrain et al., 2011)

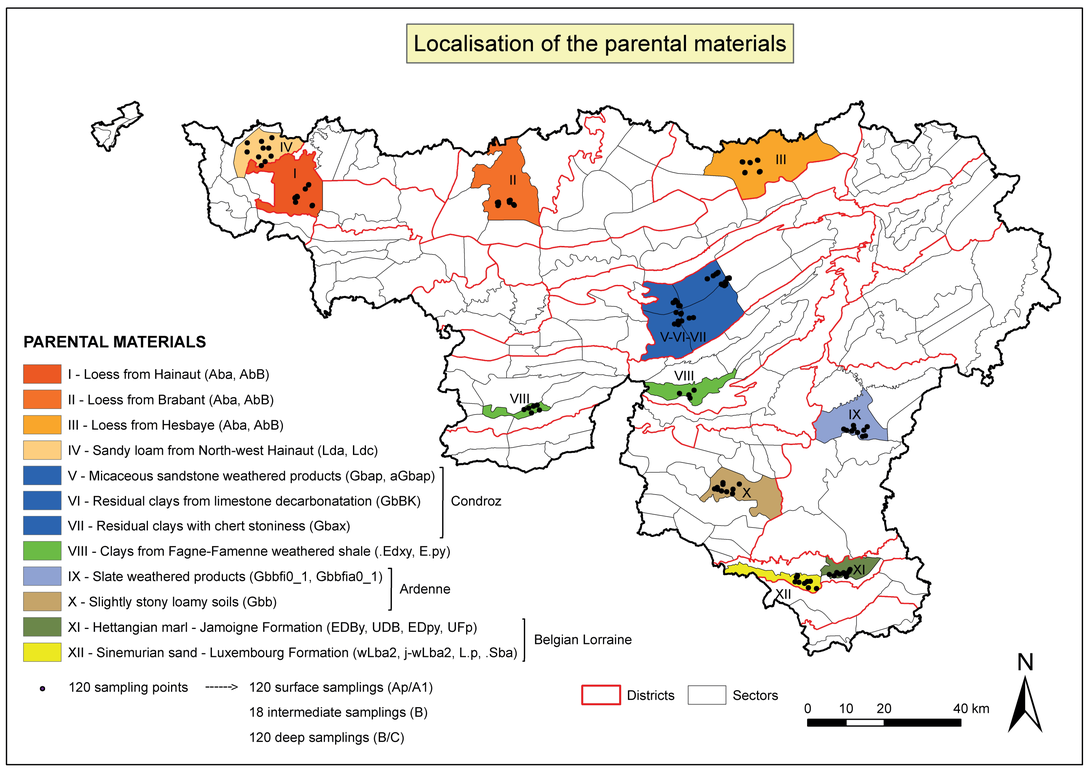
Chemical soil properties were analysed by Renneson et al., 2013

Modeling were performed with the USGS software PHREEQC Interactive 2.13.2

Chemical parameters necessary as input data to have an optimal modeling of P available in Wallonia soils were defined:

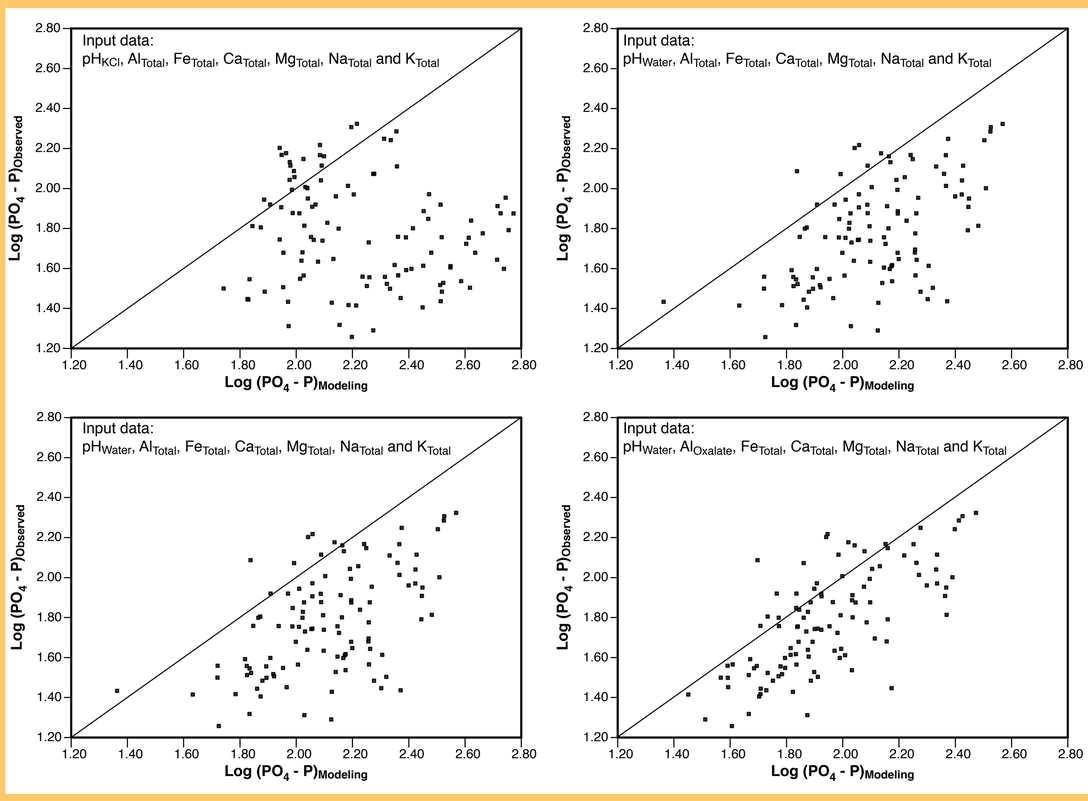
- $pH_{(Water\ or\ KCl)}$, $P_{inorganic}$, $Al_{(Total\ or\ Oxalate)}$, Fe_{Total}, Ca_{Total}, Mg_{Total}, Na_{Total} and K_{Total}

Sensitivity tests were performed to quantitatively evaluate the impact of input data variations on available P modelled



Results:

a) Calibration



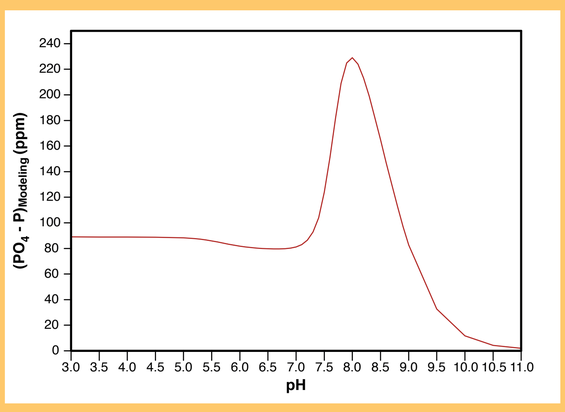
Comparisons between $(PO_4\text{-}P)_{Observed}$ and $(PO_4\text{-}P)_{Modeling}$ show which PHREEQC modeling can predict quantitatively PO_4 - P in wallon agricultural soils

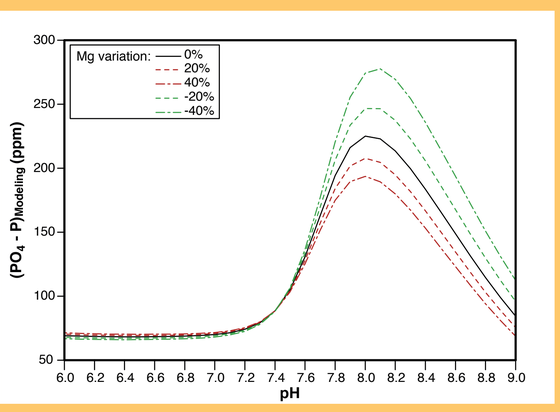
Input data calibration show which is necessary to use:

-) soil pH_{Water} rather than soil pH_{KCl}

-) soil $Al_{Oxalate}$ content rather than soil Al_{Total} content

b) Effect of pH_{Water} and [Ions]:





Sensitivity tests of pH_{water}:

-) On average $(PO_4 - P)_{Modeling}$ increase by a factor 3 when the soil pH_{Water} is raised from 7.0 to 8.0

Sensitivity tests of [Ions]:

-) Effect of [Mg] variations > [Fe] variations> [Ca] variations on $(PO_4 - P)_{Modeling}$ in wallon agricultural soils (not show)

-) [Al] variations have no effect on $(PO_4 - P)_{Modeling}$ in wallon agricultural soils (not show)

-) On average, $(PO_4 - P)_{Modeling}$ decrease of 20ppm and 40ppm, respectively, when [Mg] increase of 20% and 40%

-) On average, $(PO_4 - P)_{Modeling}$ increase of 30ppm and 50ppm, respectively, when [Mg] decrease of 20% and 40%

Conclusions:

PHREEQC modeling can predict quantitatively PO_4 - P in wallon agricultural soils

Input data which are necessary for $(PO_4 - P)_{Modeling}$ in wallon agricultural soils:

-) soil pH_{Water} rather than soil pH_{KCl}

-) soil $Al_{Oxalate}$ content rather than soil Al_{Total} content

-) For other chemical parameters, total content is suitable enough

pH effect:

-) On average, $(PO_4 - P)_{Modeling}$ in wallon soils increase by a factor 3 when soil pH_{Water} is raised from 7.0 and 8.0

[Ions] variations effect:

-) Effect of [Mg] variations > [Fe] variations> [Ca] variations on $(PO_4 - P)_{Modeling}$ in wallon agricultural soils

-) An increase of [Mg] has a negative effect on $(PO_4 - P)_{Modeling}$ in wallon agricultural soils

-) A decrease of [Mg] has a positive effect on $(PO_4 - P)_{Modeling}$ in wallon agricultural soils

-) [Al] variations have no effect on $(PO_4 - P)_{Modeling}$ in wallon agricultural soils

Perspective:

Controled studies of Mg effect on P behavior in wallon agricultural soils by batch experiments

References:

Ju et al. (2007). Environmental Pollution, 145, 497-506
Lakanen and Evrič. (1971). Acta Agralia Fennica, 123, 223-232
Legrain et al. (2011). Biotechnol. Agron. Soc. Environ., 15, 683-697
Leyten et al. (2002). Soil Science, 167, 652-658
Parkhurst and Appelo. (1999). User's guide to PHREEQC (version 2)
Ranatunga et al. (2013). Geoderma, 192, 446-452
Renneson et al. (2013). Soil Use and Management, 29, 103-113
Shang et al. (2013). Geoderma, 209-210, 22-30
Sharpley et al. (1994). Journal of Environmental Quality, 23, 437-451
Sharpley et al. (2005). Phosphorus: Agriculture and Environment, Agronomy Monography, 46, 1069-1101
Tunney et al. (2003). Juornal of Plant Nutrition and Soil Science, 166, 438-446