
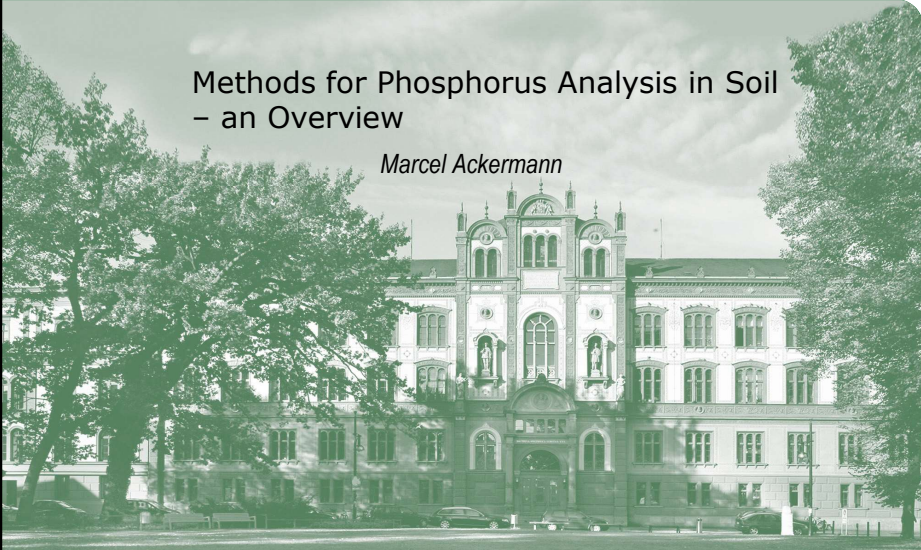



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Methods for Phosphorus Analysis in Soil – an Overview

Marcel Ackermann

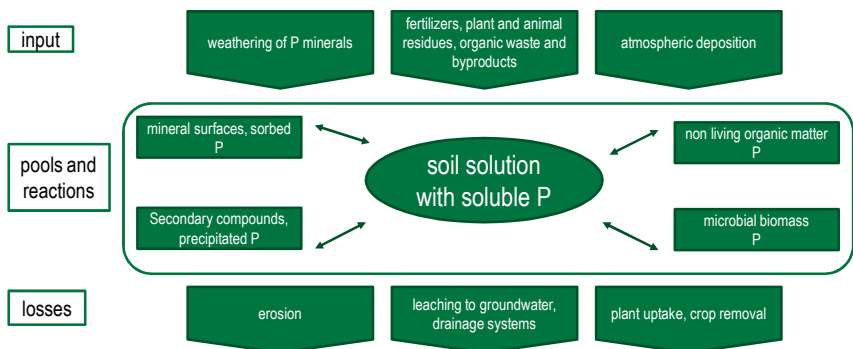


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Introduction

P cycle in soil





The diagram illustrates the phosphorus cycle in soil, centered around 'soil solution with soluble P'. It is divided into three main categories:

- input:** weathering of P minerals, fertilizers, plant and animal residues, organic waste and byproducts, atmospheric deposition.
- pools and reactions:** mineral surfaces, sorbed P; Secondary compounds, precipitated P; non living organic matter P; microbial biomass P.
- losses:** erosion, leaching to groundwater, drainage systems, plant uptake, crop removal.

Kruse et al. (2014), mod.



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Introduction

Before starting

- Which extraction processes are available for the sample matrix?
- How to prepare the samples for the chosen extraction process?
- Which P forms should be extract?

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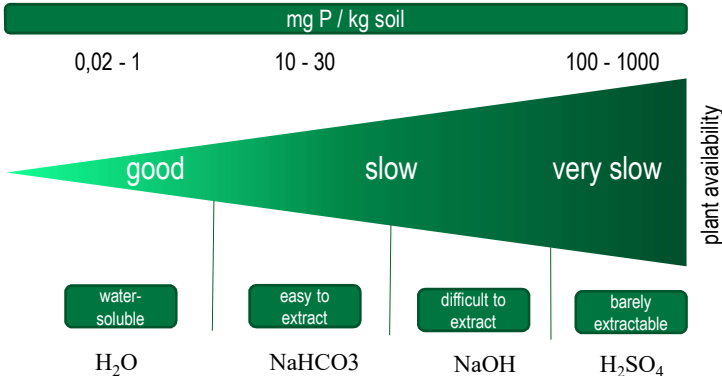


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Introduction

Plant availability of P in soil and extraction

mg P / kg soil

0,02 - 1 10 - 30 100 - 1000




good slow very slow

water-soluble easy to extract difficult to extract barely extractable

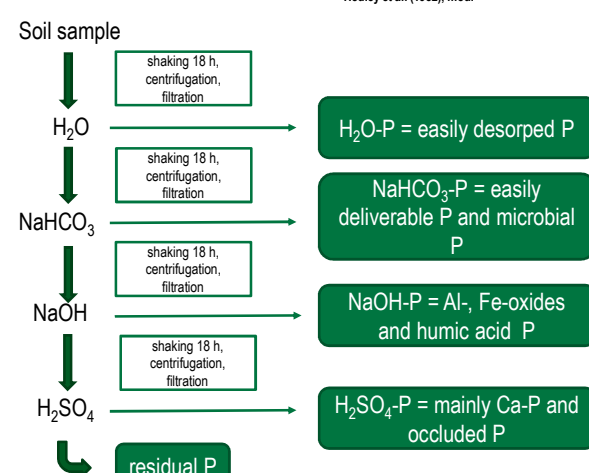
H₂O NaHCO₃ NaOH H₂SO₄

Mengel & Kirkby (2001), mod.

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P fractionation Hedley et al. (1982), mod.



Soil sample

↓ shaking 18 h, centrifugation, filtration

H₂O → H₂O-P = easily desorbed P

↓ shaking 18 h, centrifugation, filtration

NaHCO₃ → NaHCO₃-P = easily deliverable P and microbial P

↓ shaking 18 h, centrifugation, filtration

NaOH → NaOH-P = Al-, Fe-oxides and humic acid P


↓ shaking 18 h, centrifugation, filtration

H₂SO₄ → H₂SO₄-P = mainly Ca-P and occluded P

↙ residual P

Hedley et al. (1982), mod.


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Extraction of plant-available P from soil

DL (double lactate): Ca-Lactate + HCl
 CAL (calcium acetate lactate): Ca-Acetate + Ca-Lactate + acetic acid
 Ohlsen: NaHCO₃

	DL	CAL	Ohlsen
pH of solution	3.7	4.1	8.5
Soil carbonate content	< 5 %	< 15 %	> 15 %
Extracted P forms	Ca-P desorp. P Apatite	Ca-P desorp. P	Ca-P adsorp. P



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Extraction of plant-available P from soil

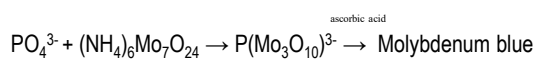
DL (double lactate): Ca-Lactate + HCl
 CAL (calcium acetate lactate): Ca-Acetate + Ca-Lactate + acetic acid
 Ohlsen: NaHCO_3

	DL	CAL	Ohlsen
pH of solution	3.7	4.1	8.5
Soil carbonate content	< 5 %	< 15 %	> 15 %
Extracted P forms	Ca-P desorp. P Apatite	Ca-P desorp. P	Ca-P adsorp. P



H_2O : easily desorped P, water-soluble fertilizer P
 citric acid: P-stock in mineral soil horizons of forests

Molybdenum blue

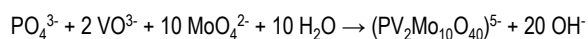


- unstable reaction
- linearity range (885 nm): 0.002 – 2.5 mg P / l
- not for HNO_3 extracts



mg P / l

Vanadate-molybdate yellow



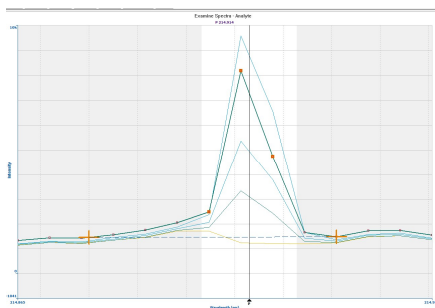
- stable reaction
- linearity range (430 nm): 0.3 - 20 mg P / l
- possible for HNO_3 extracts



mg P / l

Inductively Coupled Plasma – Optical Emission Spectroscopy (ICP – OES)

- Simultaneous measurement of different elements
- Almost every matrix and extraction agent
- Organic Phosphorus

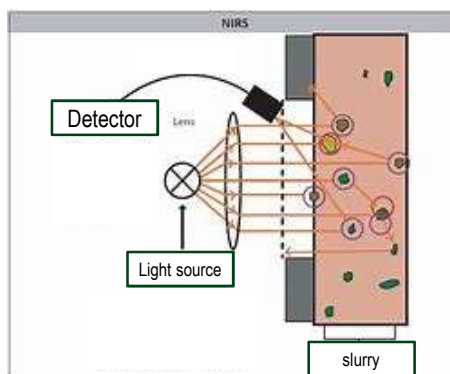


Near Infra Red Spectroscopy (NIRS)

- NIR reflection / absorption
- indirect quantification
- cost- and time-effective



<https://www.topagrar.com/acker/news/nachstoff-schwankungen-in-guelle-nirs-sensor-regel-punktgenau-11839344.html>



Eutrophication of aquatic ecosystems

- P as limited resource
- Loss of 5000 t P / a by erosion (Germany)



<https://wbv-harthe-kueste.de/gewaesserunterhaltung/krautung/>



Bioplan Nienhagen



<https://upload.wikimedia.org/wikipedia/commons/7/7b/Erosion.jpg>

Eutrophication of terrestrial ecosystems

- nutrient poor sandy grasslands
- plants adapted to low production sites



Thank you very much for your attention!

