Soil phosphorus pools and their relation to land-use and soil physiochemical properties

A case study of an agricultural watershed in north-eastern China

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Water shortage

- Shortage of freshwater - A global problem
  - China - ¼ of the world average (per capita)

- UN development goal 7.C
  - *aims at reducing the worlds population without access to safe drinking water with 50% by 2015*

- Eutrophication is the most widespread water quality problem in the world, and is one of the main environmental challenges in China
Eutrophication

- Increased flux of nutrients to surface waters
  - Phosphorus is usually the limiting nutrient in freshwaters

- Associated with several problems
  - Change in odour, colour and taste
  - Blooms of cyanobacteria that may produce toxins
  - Alterations in the ecosystems - decreased biodiversity

- Sources of phosphorus
  - Point
  - Non-point
Yuqiao reservoir

- Increasing trend of eutrophication
Yuqiao reservoir

- Increasing trend of eutrophication
- Main source of drinking water for 6.3 million people
- Recreational activities, fishing and a water source for industry

Photocredits: Jon Naustdalslid & Ellen Pettersen
Site description

- Between 120 000 and 140 000 habitants
- Farming and animal husbandry
- Main agricultural land-use are farmlands, orchards and vegetable areas
- 25% of the area is covered by forest
Site description

- Extensive use of fertilizers
  - Farmers apply \( \sim 17.4 \, \text{g P/m}^2 \) every year
  - The average in Norway is 1.9 g P/m\(^2\)

- In addition there is limited sewage and waste water treatment in the area
Aim of study

- Assess the spatial variation of phosphorus pools and how it is related to land-use management

- How the physiochemical properties of the soil are related to the phosphorus pools and how they affect the phosphorus leaching
Soil sampling and analysis

- Sampling in January and June 2013.
  - Geographical distribution
  - Land-use
  - Soil horizons.

- Follow-up to a previous master study.
Soil sampling and analysis

- Pre-treatment
  - Dried and sieved
  -Stored dark at room temperature

- Physiochemical parameters
  - Organic matter, pH, soil texture, mineralogy and phosphorus pools
  - $\text{CEC}_e$, phosphorus sorption capacity and $^{31}\text{P-NMR}$

- Compilation of data
Soil-water sampling and analysis

- Lysimeters

- Soil-water analysed at TAES
  - pH, TOC, Major ions and phosphorus fractions
Physiochemical properties through the soil horizons (A, B and C layer)

- **Expected**
  - Decreasing pH
  - Decreasing OM content
  - Decreasing TP concentrations

- **Observed**
  - No clear trend in pH
  - Decreasing OM content in orchards and vegetable fields. No trend in farmlands
  - Decreasing TP concentrations
Principal component analysis

- Soil horizon is main explanatory factor for the size of phosphorus pools
Soil phosphorus pools (A horizon)

- Low concentrations
  - Median values < 1000 mg P/kg
- No large difference between land-use
Soil phosphorus pools (A horizon)

- Inorganic phosphorus dominant in all land-use

![Bar chart showing the percentage of inorganic and organic phosphorus in different land-use types.]
Why is the soil phosphorus concentrations so low in the Yuqiao watershed?
Soil physiochemical properties (A horizon)

- pH

**Results**
Soil physiochemical properties (A horizon)

- Organic matter
Soil physiochemical properties (A horizon)

- Soil texture
  - Silt and sand dominates

- $C_{EC_e}$

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Results
Phosphorus sorption capacity

- Median values between 200 and 300 mg P/kg
- Oversaturation of phosphorus
Soil-water phosphorus pools (A horizon)

- Free inorganic phosphate dominates
Transport of phosphorus
The cluster analysis was performed on 68 samples and all the physiochemical parameters.

Two clusters:
- Forest and orchard together with OM and sand
- Vegetable fields, soil pH and finer soil particles
When including P-pools there is a shift in the clustering.

Phosphorus pools are independent of soil properties.
Conclusions

- No clear trends in physiochemical parameters through the soil horizons – except for total phosphorus

- The soils from different land-use do not differ significantly with regards to the studied physiochemical parameters

- Low P concentrations due to the low sorption capacity – oversaturation of phosphorus

- Erosion and surface runoff important transport mechanisms.

- Cluster and PCA analysis indicates that phosphorus pools are dependent on the land-use practices.