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Drivers and pressures governing transport of phosphorous fractions

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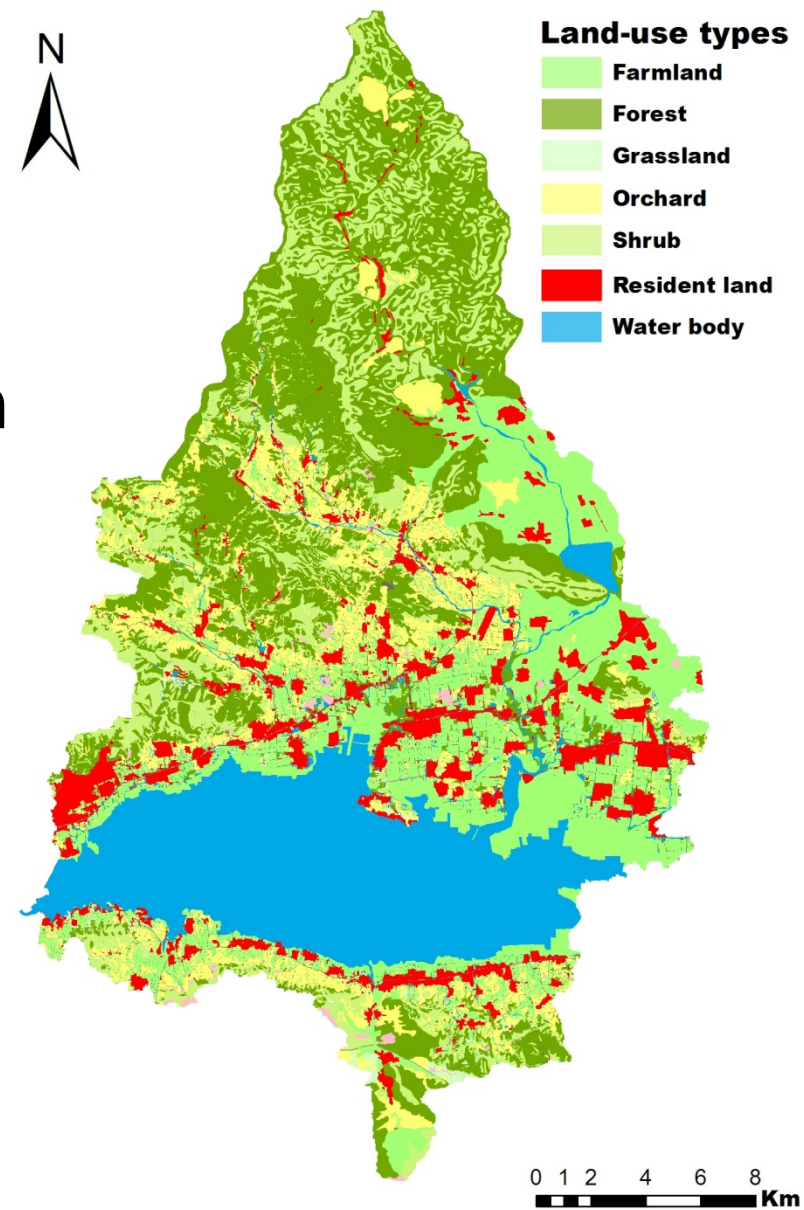


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Drivers of P loading

- Approx. **105 000 people** live in the watershed and work within agricultural production



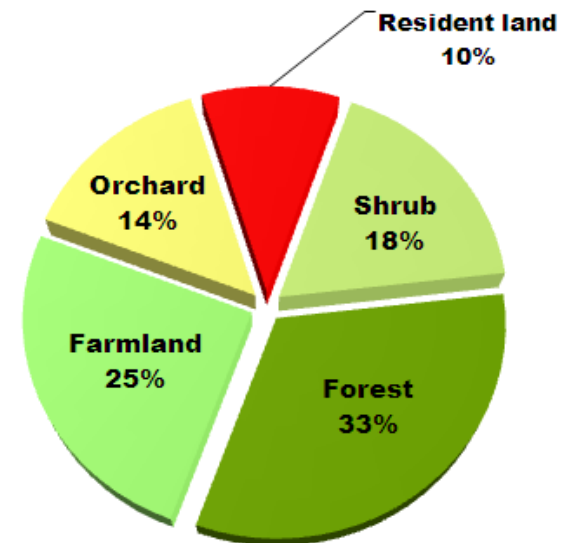
Drivers of P loading

- Approx. 105 000 people live in the watershed and work within agricultural production
- Huge livestock
 - 106 000 pigs,
 - 6 000 cattle,
 - 16 000 sheep
 - 805 000 poultry



Drivers of P loading

- Approx. 105 000 people live in the watershed and work within agricultural production
- Huge livestock
 - 106 000 pigs,
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 - 805 000 poultry
- **Farmland** and **orchard** constitute 40% of the watershed
- Most farmland lie at the vicinity of the reservoir

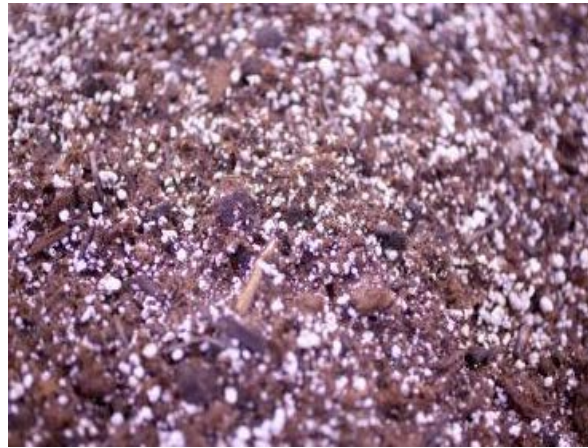


Pressures of P loading

Three main P sources

1. Over-application of inorganic P fertilizer

The farmers apply $\sim 9 \text{ g P m}^{-2} \text{ yr}^{-1}$ inorganic fertilizers



Pressures of P loading

Three main P sources

2. A large amount of manure from excess livestock and poultry breeding

Only a small part of it is used in the fields due to excess amounts and labor demanding.

Most is just dumped due to lack of collection system



Pressures of P loading

Three main P sources



3. Large contribution of sewage from household

Most of household's sewage is directly discharged into nearby channels or rivers due to the lack of sewage treatment system



Percentage of pollutant loss by pollution sources

Pollution sources	COD		Ammonia nitrogen		Total nitrogen		Total phosphorus	
	Loss (tons)	Percentage (%)	Loss (tons)	Percentage (%)	Loss (tons)	Percentage (%)	Loss (tons)	Percentage (%)
Fertilizers and pesticides	1026	3.6	437	17	3516	40	825	33
Livestock and poultry raising	19995	70	1697	66	4186	48	1291	52
Rural residential pollution	7631	27	447	17	1055	12	384	15

Source: Tianjin Dragon Network Technology Development Co Ltd, *Study on Diffused Pollution in the River in the Prefecture and Measures*, the report of 2014

In: Jintu et al., In progress



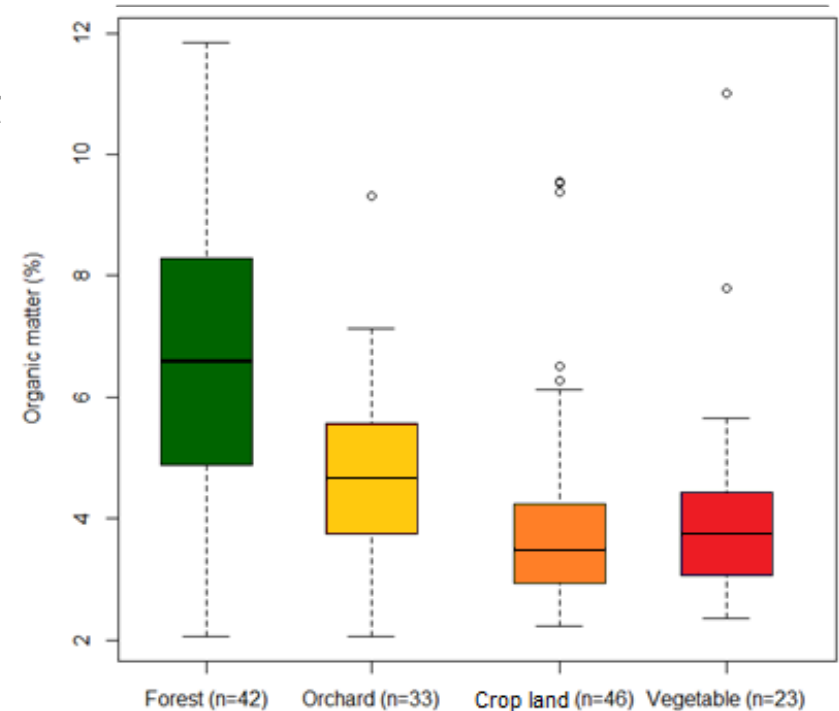
Clean water action plan

- \$330 billion to curb water pollution
- Efforts must be put on diffuse sources
– not on point sources, i.e. not upgrading existing sewage treatment plants

Main results

- Soil chemistry

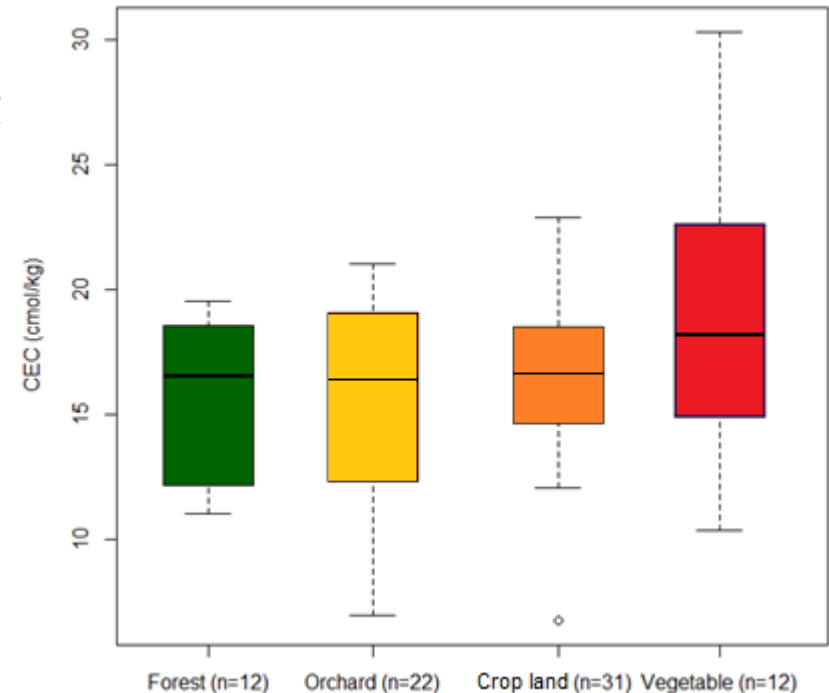
- Low Soil organic matter content



Main results

- Soil chemistry

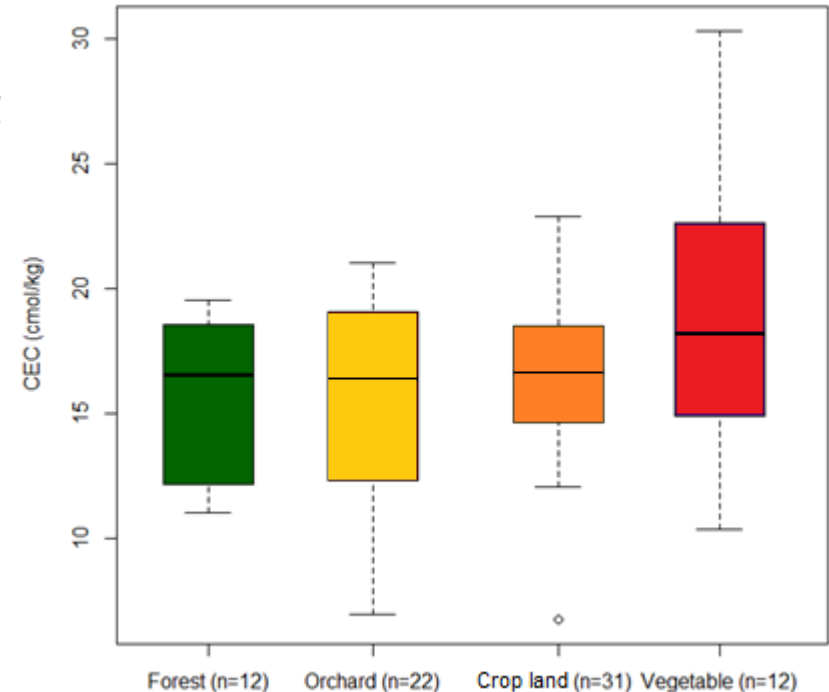
- Low
Soil organic matter content
- Low
Cation exchange capacity



Main results

- Soil chemistry

- Low
Soil organic matter content
- Low
Cation exchange capacity
- Soil texture
 - Homogeneous particular size distribution of mainly silty loam
 - Apparent impermeable clay layer underneath shallow Ap

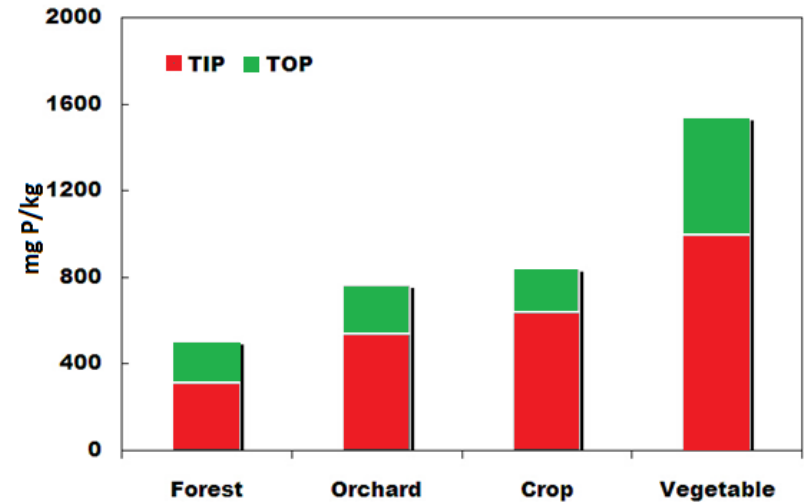


Main results

- Soil chemistry

- P pools
 - Total inorganic P (TIP) is the dominant fraction (60~80%)

State

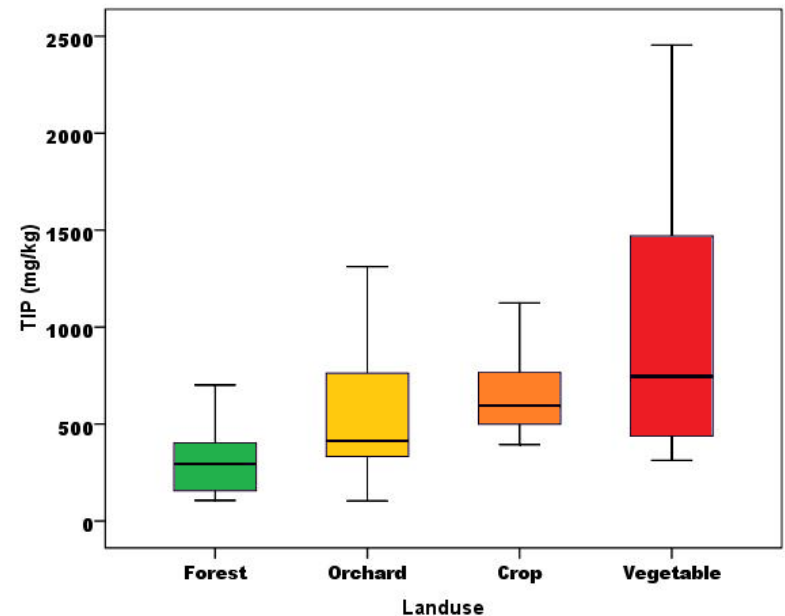


Main results

- Soil chemistry

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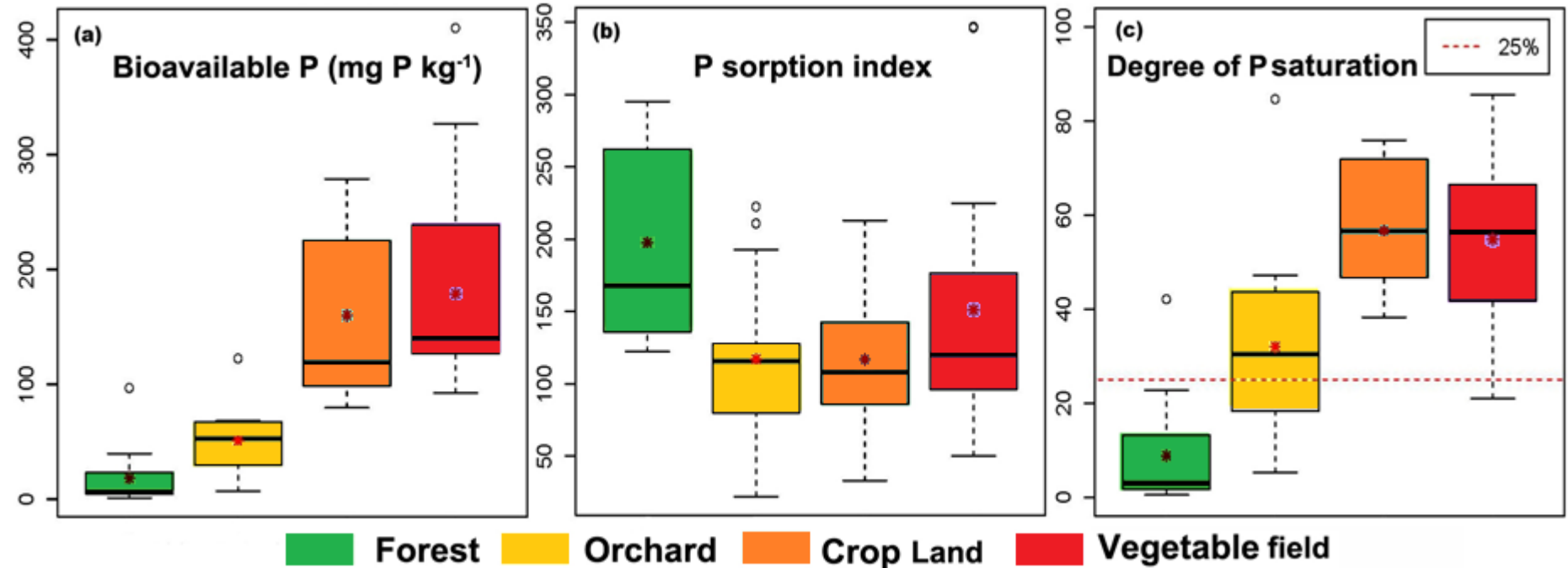
- P pools
 - Total inorganic P (TIP) is the dominant fraction (60~80%)
- TIP increased in the following order:
 - Forest < Orchard < Crop land < Vegetable field
 - P pools are strongly governed by P fertilizer application



In: Master thesis of Joshi (2014) & Pettersen (2014)



P sorption capacity



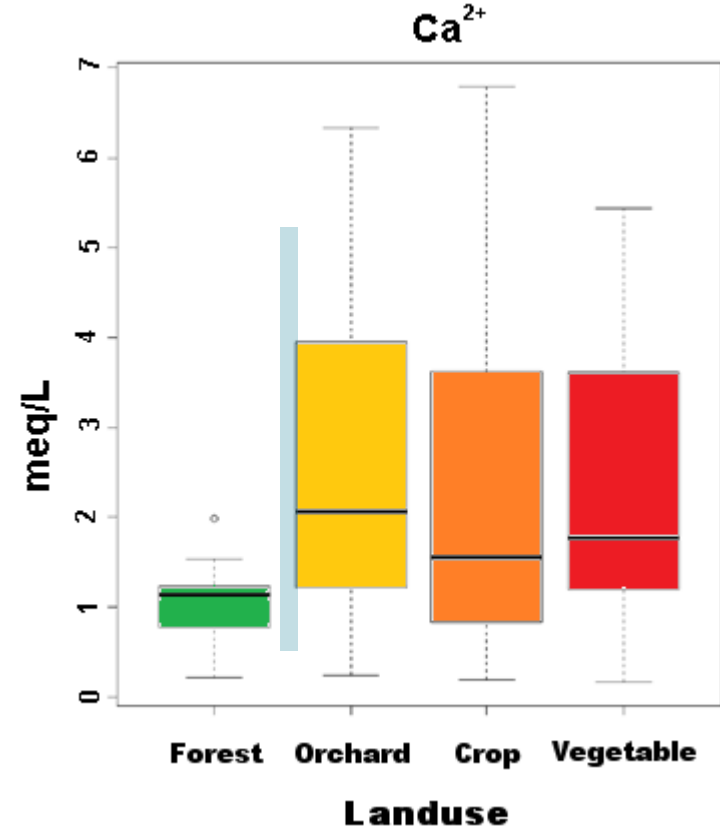
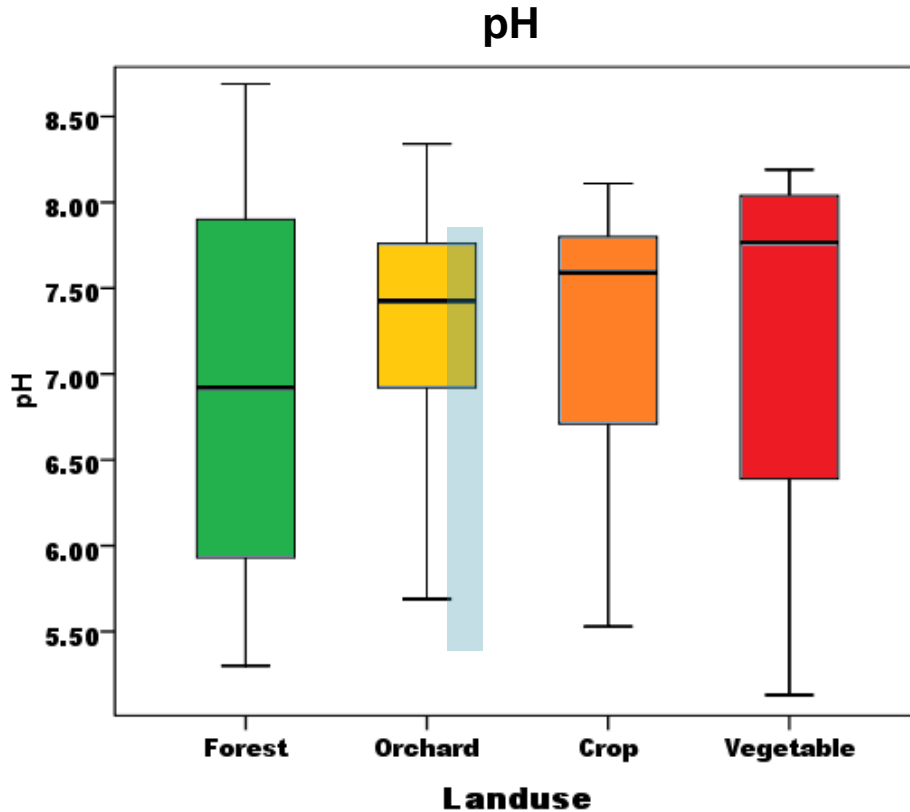
- **Bio-available P** is governed by agricultural management practices
- **P sorption capacity** (P sorption index) is very low
- **The Degree of P saturation** exceeds the critical threshold value in all land-use types, except for forest soils

Main results - Water chemistry

State

pH between 7-7.5 with high conc. of Ca^{2+}

➤ PO_4 solubility is expected to be governed by apatite solubility.



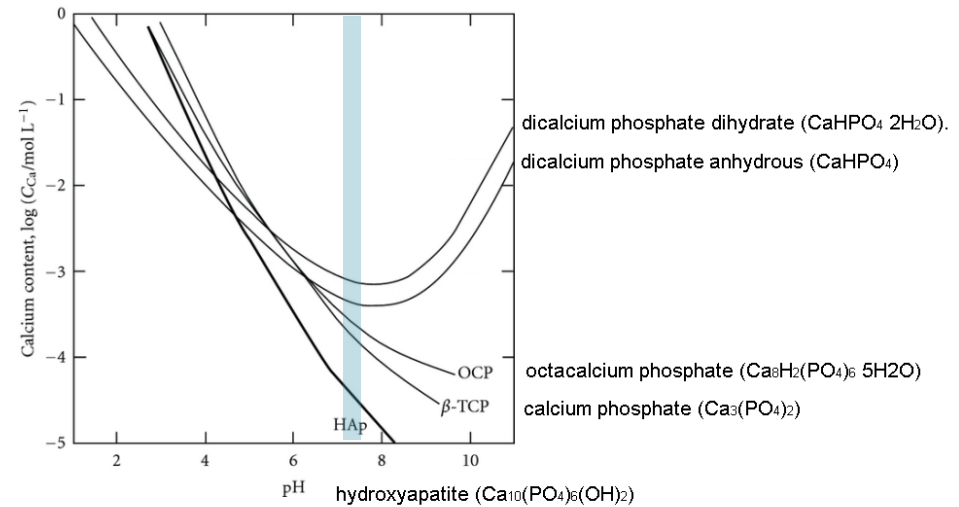
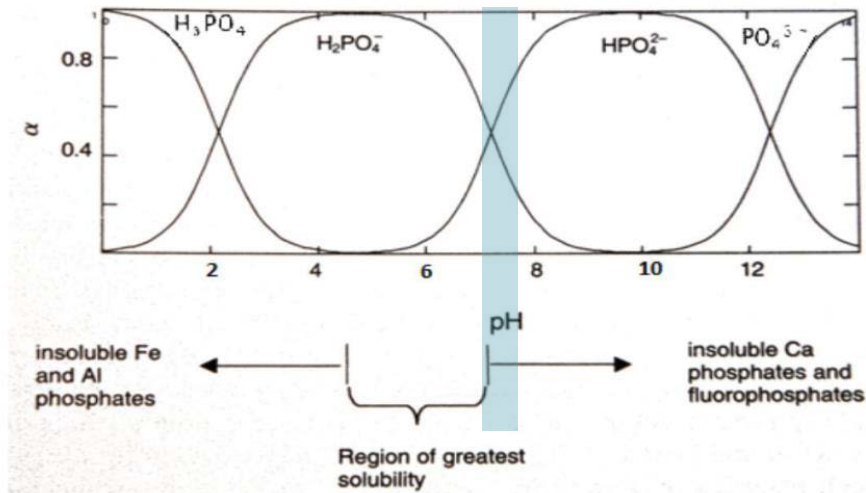
In: Master thesis of Wycliffe (2014)

Main results - Water chemistry

State

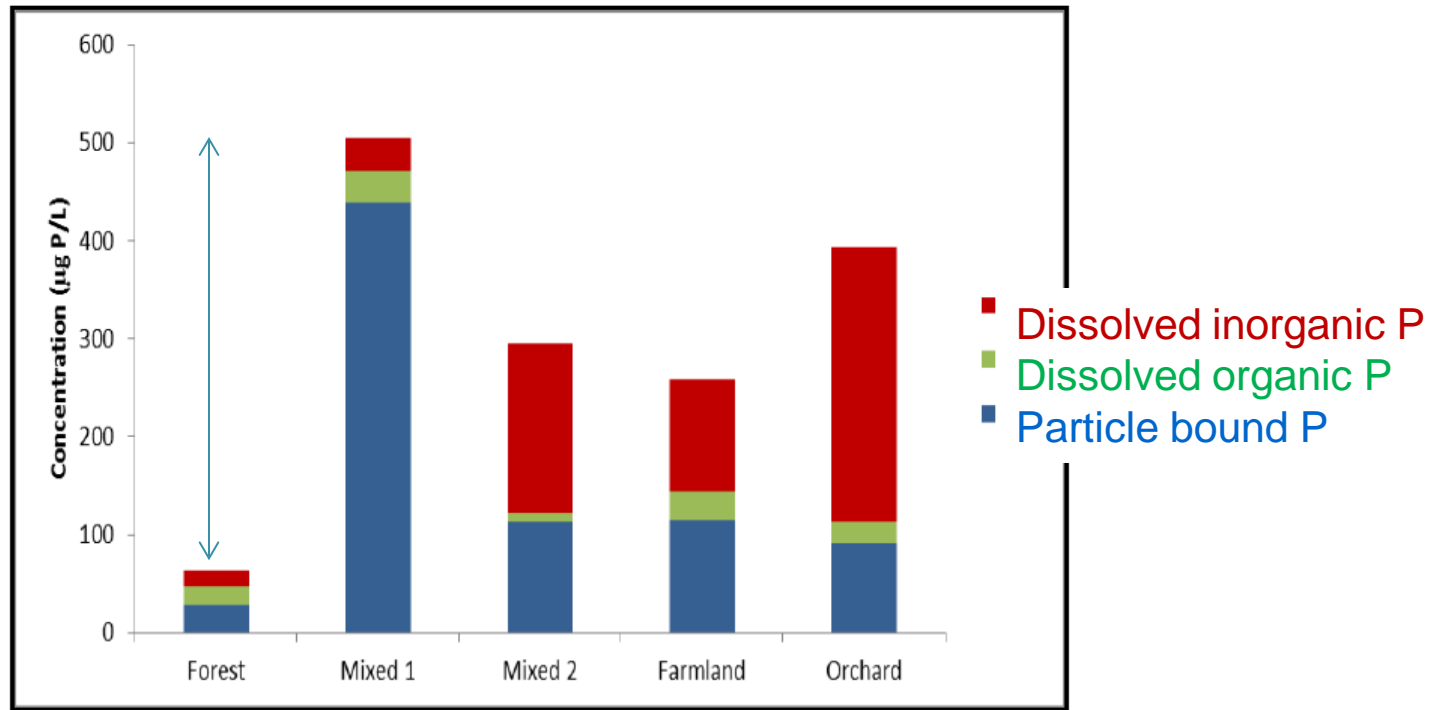
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Main results - Water chemistry

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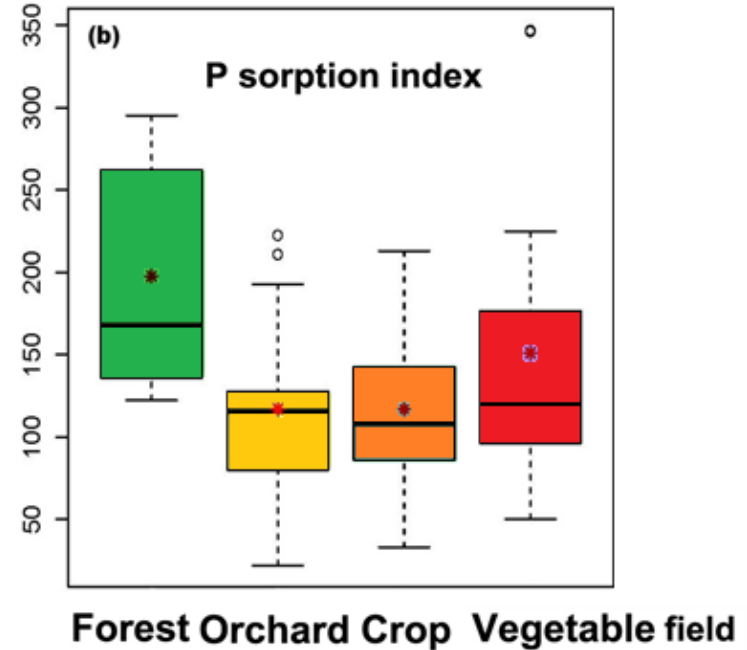
- P fractions

- Mean Total P in the river water between **60-500 $\mu\text{g P/L}$**
- **Dissolved Inorganic P** is the dominant fraction in all local streams draining mainly agricultural land
- **Particulate P** is the main fraction only in the main large river - governed by a large suspended particle loading from industry

In: Master thesis of Wycliffe (2014)

Main findings – nature sciences

- The soils have very poor P sorption ability and are strongly P oversaturated
- Excess P is not retained
- Frequent application of manure and fertilizers is based on indigenous knowledge
- Amount added has no clear consideration of poor soil P sorption capacity



Recommendations

- Close the P cycle

- Reuse:
 - Collect dung from husbandry and sewage from households
 - Process in central units producing methane, fertilizers and dry manure for export



Recommendations

- Close the P cycle

- Reduce inorganic fertilizing
 - Make available
 - Smaller fertilizer bags
 - Fertilizers without P
 - Plough deeper
 - Limit cultivation of vegetables
 - Improve literacy
 - Disseminate information
 - Provide advice based on soil analysis



Recommendations

- Close the P cycle

- Recycle:
 - Convert decommissioned fish ponds to constructed wetlands
 - Capture eroded soil and Bioavailable P



