SinoTropia

Modeling of the potential phosphorus leaching risk from micro to macro scale

B. Zhou[1,2], R.D. Vogt[1], C. X[2], X. Lu[3]

[1] Department of Chemistry, University of Oslo
[2] Department of Geosciences, University of Oslo
[3] Tianjin Academy of Environmental Sciences

2015.03 (Beijing)

UNIVERSITY OF OSLO

NIVA Norwegian Institute for Water Research

NIBR Norsk institutt for by- og regionforskning

The main issue

■ 60 - 70% of the surface water resources in China have too poor quality

■ Eutrophication is the main cause for poor ecological Quality

■ phosphorus (P) leaching from agricultural land is usually the main cause for freshwater eutrophication

bin.zhou@kjemi.uio.no

Introduction

Key words: Eutrophication Phosphorus P leaching risk

Paper I

Establishment and Validation of an Amended Phosphorus Index: Refined P Loss Assessment of an Agriculture Watershed in Northern China

To build a spatial assessment model to identify the hotspots for P leaching risk Where and how?

Paper II

Relative Importance Analysis of a Refined Multi-parameter Phosphorus Index Employed in a Strongly Agriculturally Influenced Watershed

To build a importance evaluation model to determine the relative significance of each parameter to the final P index value Controlling factor?

Paper III

Land use as explanatory factor for potential phosphorus leaching risk, assessed by P indices, 31P-NMR speciation and enzyme activity

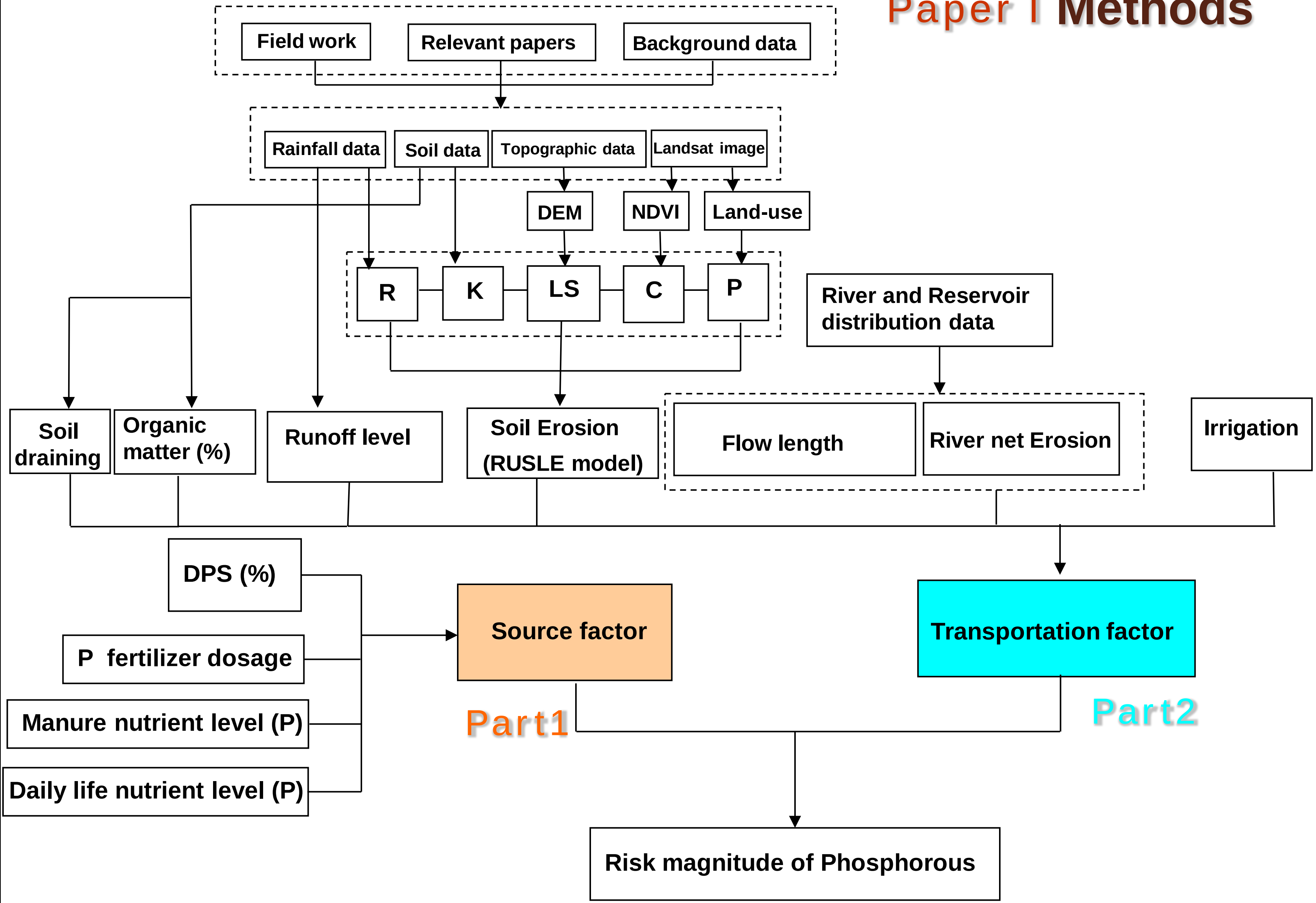
Paper IV

Kinetics and mechanisms of phosphorus adsorption and desorption behavior in soil

Using different P chemical and physical indices to focus further soil P fractions, to capture the real reason of P leaching based on soil physiochemical properties

bin.zhou@kjemi.uio.no

Paper I Methods



The structure of amended Phosphorus Index

Soil erosion

RUSLE model: A=R*K*LS*C*P

$$R = \sum_{i=1}^{12}\left[1.735\times10^{1.5\times\lg(Pi^2/P)-0.8188}\right]$$

$$K = \left\{0.2+0.3\exp\left[-0.0256S_d\left(1-\frac{S_i}{100}\right)\right]\right\}$$

$$\times\left[\frac{S_i}{C_l+S_i}\right]^{0.3}\times\left\{1-\frac{0.25C}{C+\exp(3.72-2.95C)}\right\}$$

$$\times\left\{1-\frac{S_d}{100}+\exp\left[-5.51+22.9\left(1-\frac{S_d}{100}\right)\right]\right\}$$

$$LS = \left(\frac{\lambda}{22.1}\right)^m\times(65.41\times\sin^2\theta+4.56\times\sin\theta+0.065)$$

$$\begin{cases} m=0.2 & slope<1\% \\ m=0.3 & 1\%\le slope\le 3\% \\ m=0.4 & 3\%<slope<5\% \\ m=0.5 & slope\ge 5\% \end{cases}$$

$$\begin{cases} C=1 & I_c=0 \\ C=0.6805-0.3436\lg I_c & 0<I_c<78.3 \\ C=0 & I_c>78.3 \end{cases}$$

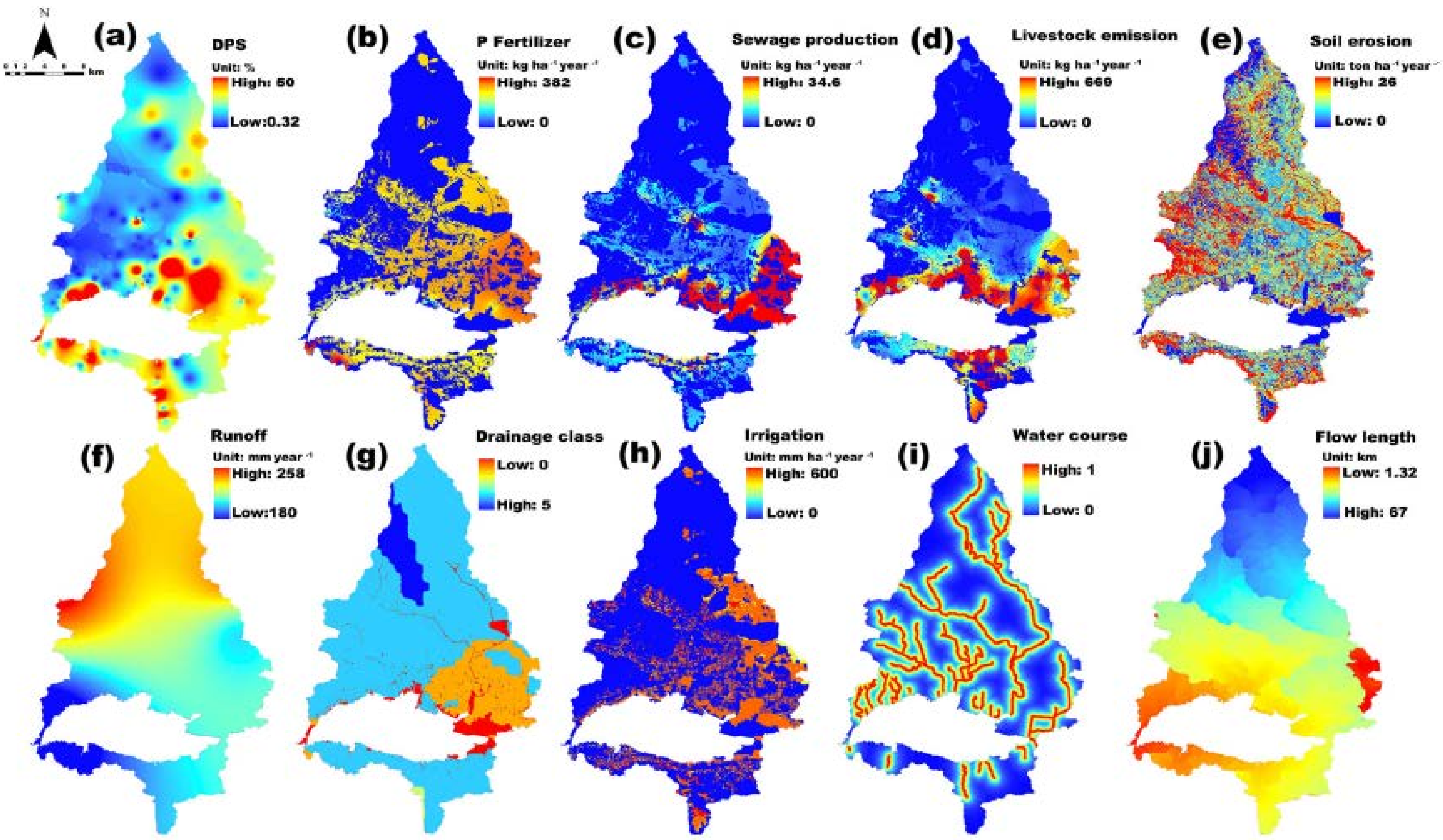
$$I_c = 108.49NDVI+0.717$$

$$PI = \left[\sum S_\alpha w_\alpha\right]\times\left[\sum TD_\beta w_\beta\right]\times\left[\sum TE_\gamma W_\gamma\right]$$

bin.zhou@kjemi.uio.no

Results and discussion

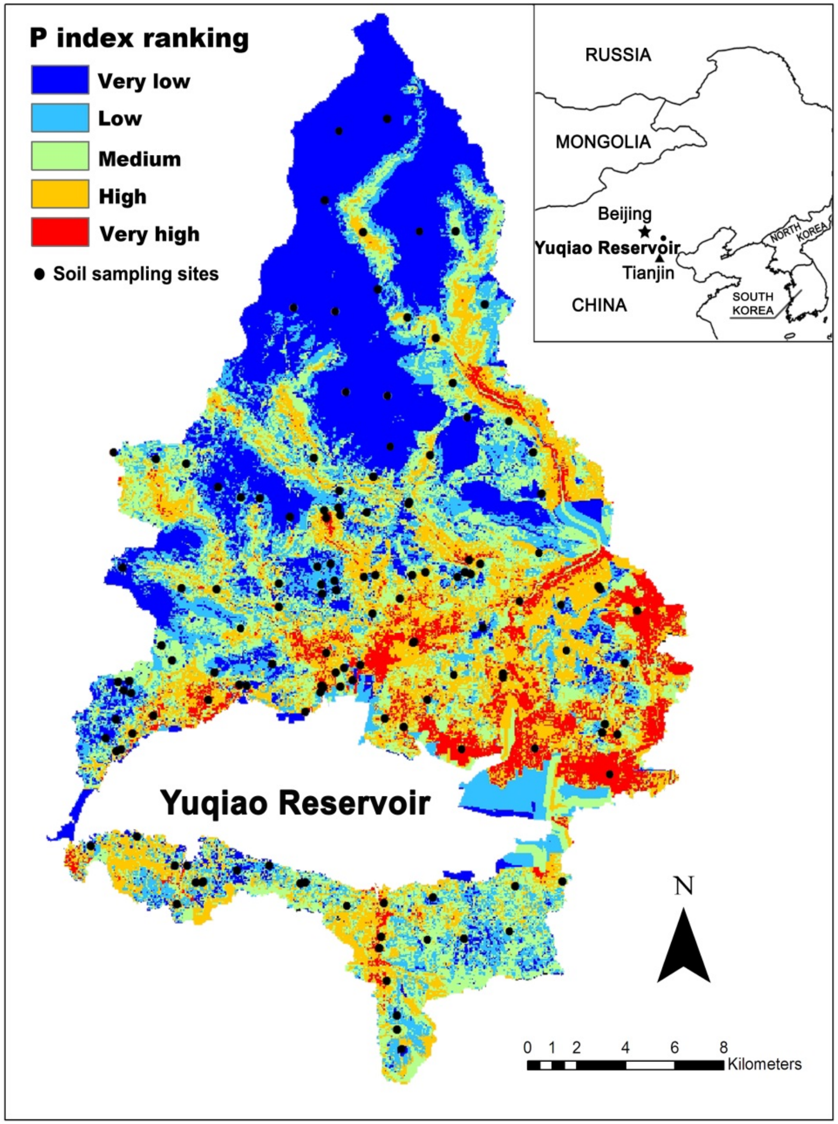
Spatial distribution maps of source and transportation factors



bin.zhou@kjemi.uio.no

Paper I Results and discussion

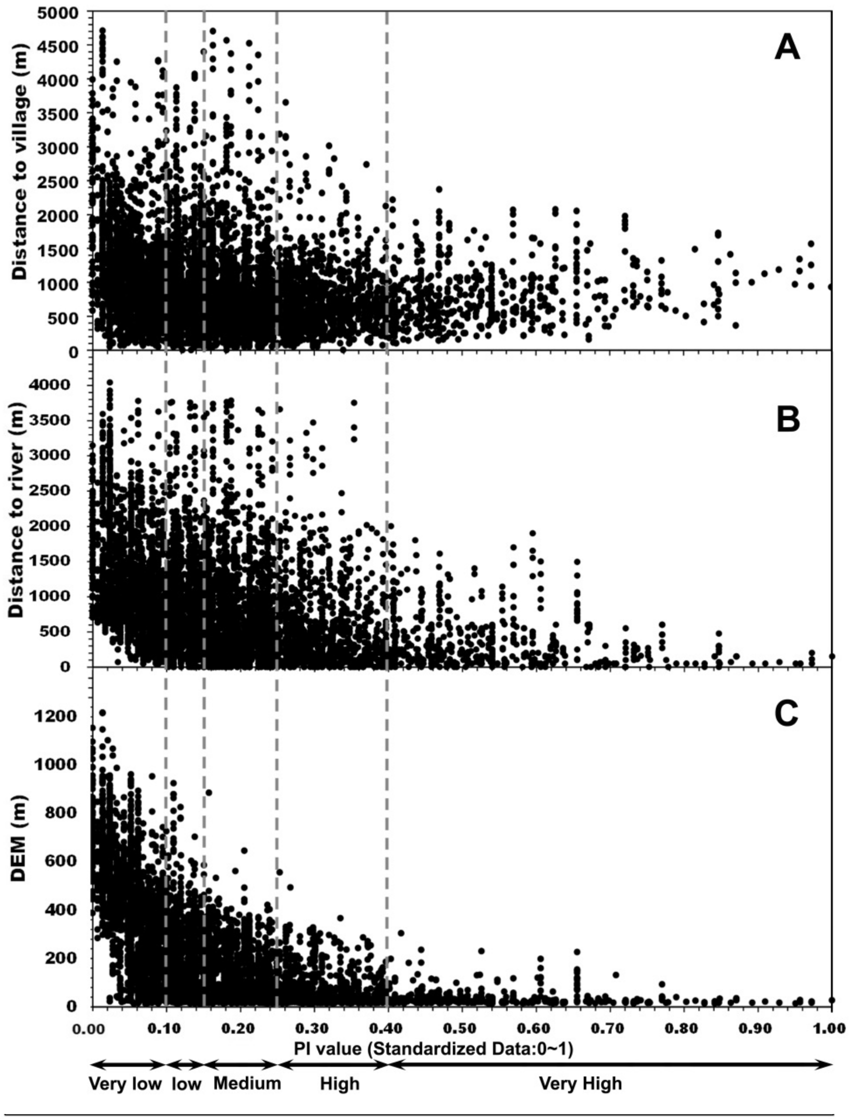
The primary direct finding of the current research is that the areas with close proximity to rivers and the reservoir



Paper I Results and discussion

The primary direct finding of the current research is that the areas with close proximity to rivers and the reservoir

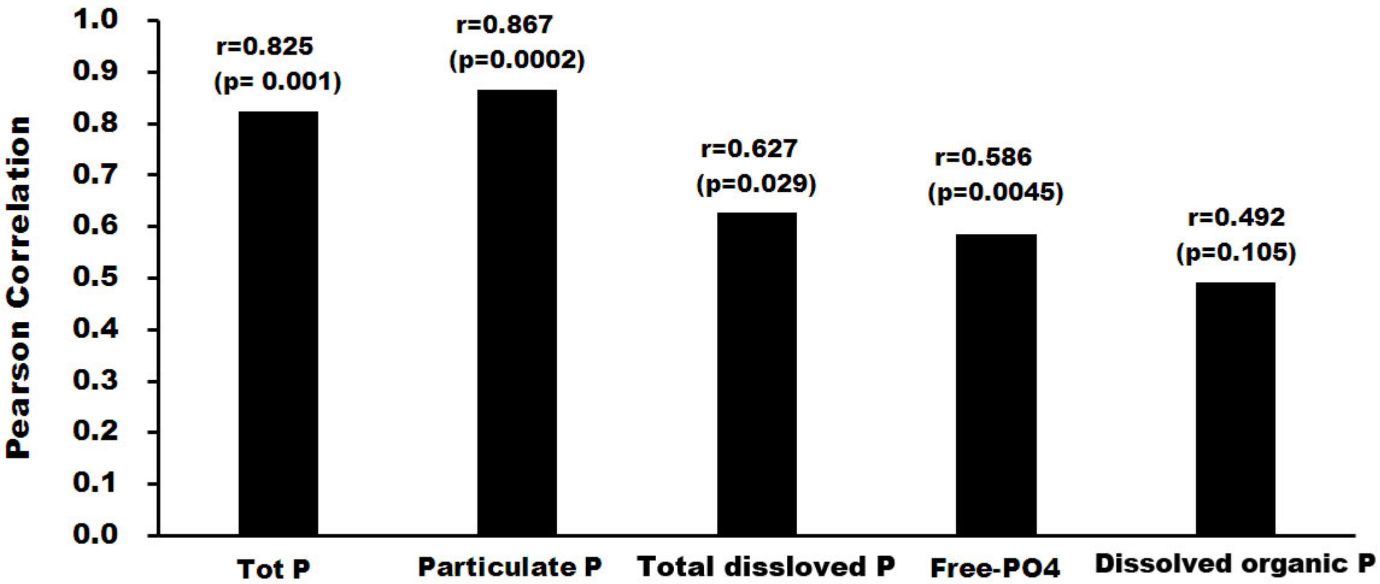
as well agricultural land around villages, are found to be the main hot-spots sources for P loss to the reservoir



Paper I **Results and discussion** Validation

Correlation coefficient (Pearson)

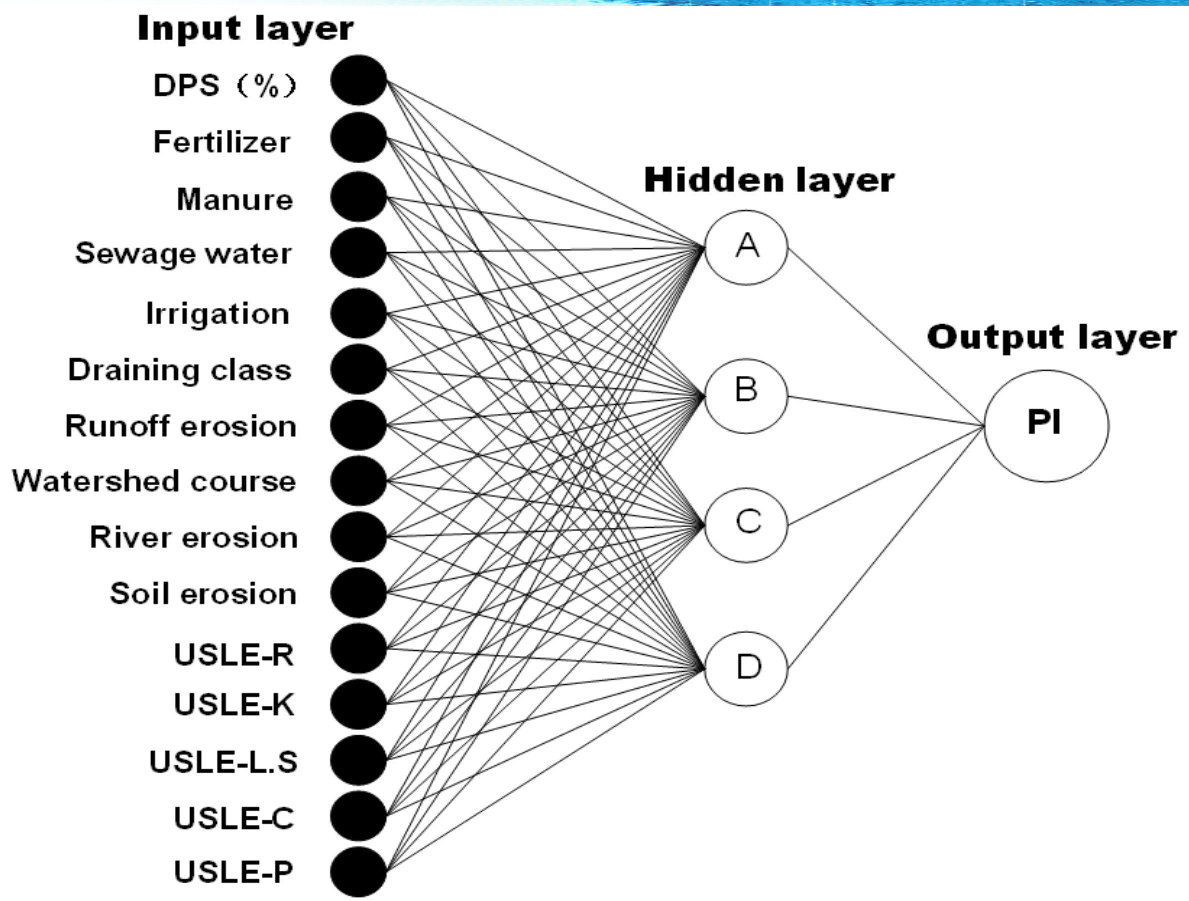
12 sub-catchments were chosen



bin.zhou@kjemi.uio.no

Paper II Methods

The backpropagation network (BPN)

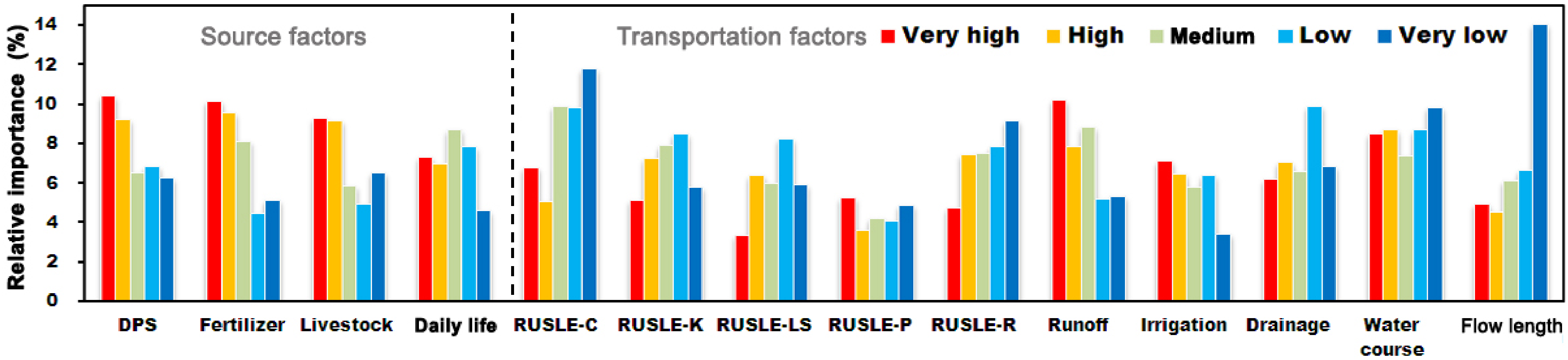


Garson algorithm

$$Q_{ik} = \frac{\sum_{j=1}^{L} \left| w_{ij} v_{jk} \right| / \sum_{r=1}^{N} \left| w_{rj} \right|}{\sum_{i=1}^{N} \sum_{j=1}^{L} \left(\left| w_{ij} v_{jk} \right| / \sum_{r=1}^{N} \left| w_{rj} \right| \right)}$$

bin.zhou@kjemi.uio.no

Results and discussion



Different risk zones have different controlling factors

- The very high risk area is strongly governed by the source factors
- Transportation factors governed the overall P loss risk in the low and very low risk areas

Make us easier to understand the key controlling factor for each risk zone, then give us more direct guideline to mitigate P leaching risk

bin.zhou@kjemi.uio.no

Introduction

In this study, we mainly focused on the physiochemical characteristics o f soils.

- **P pools**

  Tot P, TIP, TOP

- **P potential loss risk indices**

  BAP: Olsen P, Bray-1 P, Mehlich 3 P

  PSI: P sorption index

  DPS%: Degree of P saturation

- **P Soil P composition ^{31}P NMR**
- **Phosphatase activities**

  AcP, AlP, PD and PY

- **General characteristics**

  pH, Organic matter (LOI%), PSD (Clay, Silt and Sand%), bulk density, CECe, Soil mineral composition (XRD)

- Overall P pools reveals the general soil P level.

- Bio-available P (BAP), P sorption index (P SI) and degree of P saturation (% DPS) in the soils are commonly applied as proxies for assessing the risk of P leaching.

- Detailed soil P speciation was conduct ed using phosphorus nuclear magnetic resonance (31P NMR) spectroscopy.

bin.zhou@kjemi.uio.no

Main findings - soil chemistry

pH

Circumneutral or slightly alkaline soil

Soil organic matter

Low organic content (from 3.5 to 6.8%)

Soil texture

Homogeneous particular size distribution of mainly silty loam

Soil mineral composition

Phosphorus containing minerals were not found.
This implies that the P in the soil is mainly from agricultural activity

P pools

- Total inorganic P (TIP) is the dominant fraction (60~80%)
- TIP and bio-available P level were in the following order:

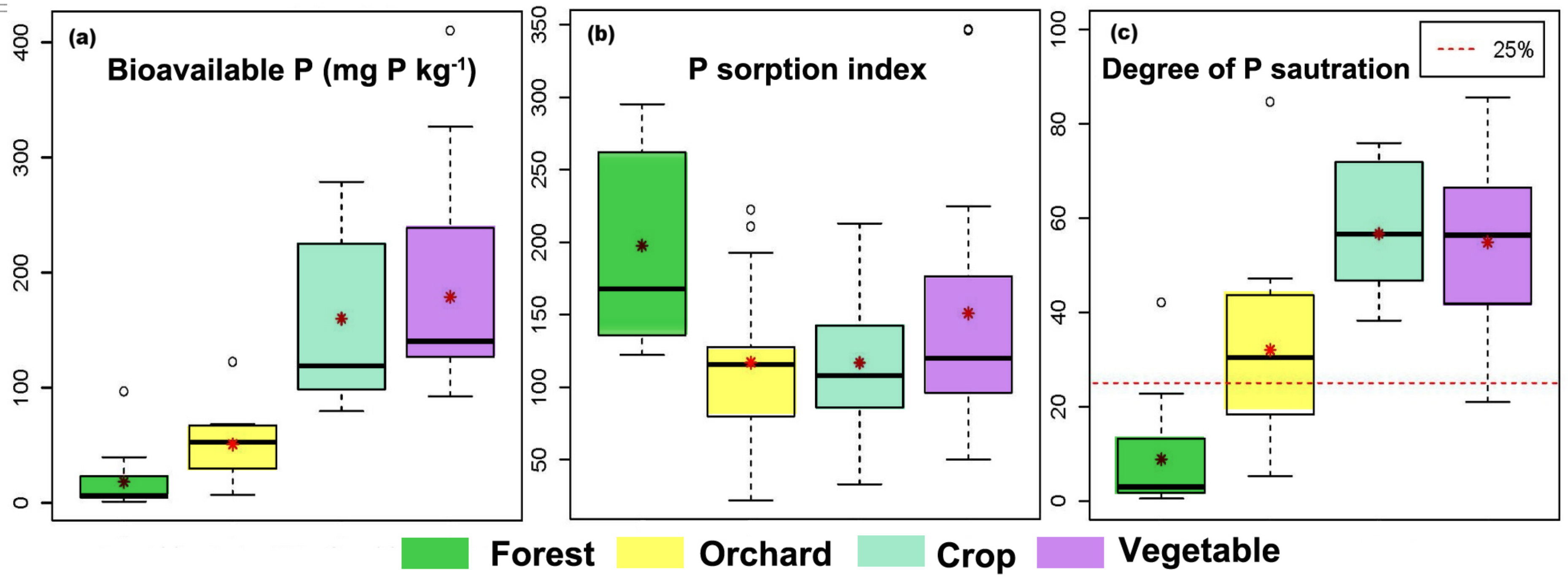
Forest < Orchard < Crop land < Vegetable field

P pools are strongly governed by P fertilizer application

bin.zhou@kjemi.uio.no

Main findings - soil chemistry

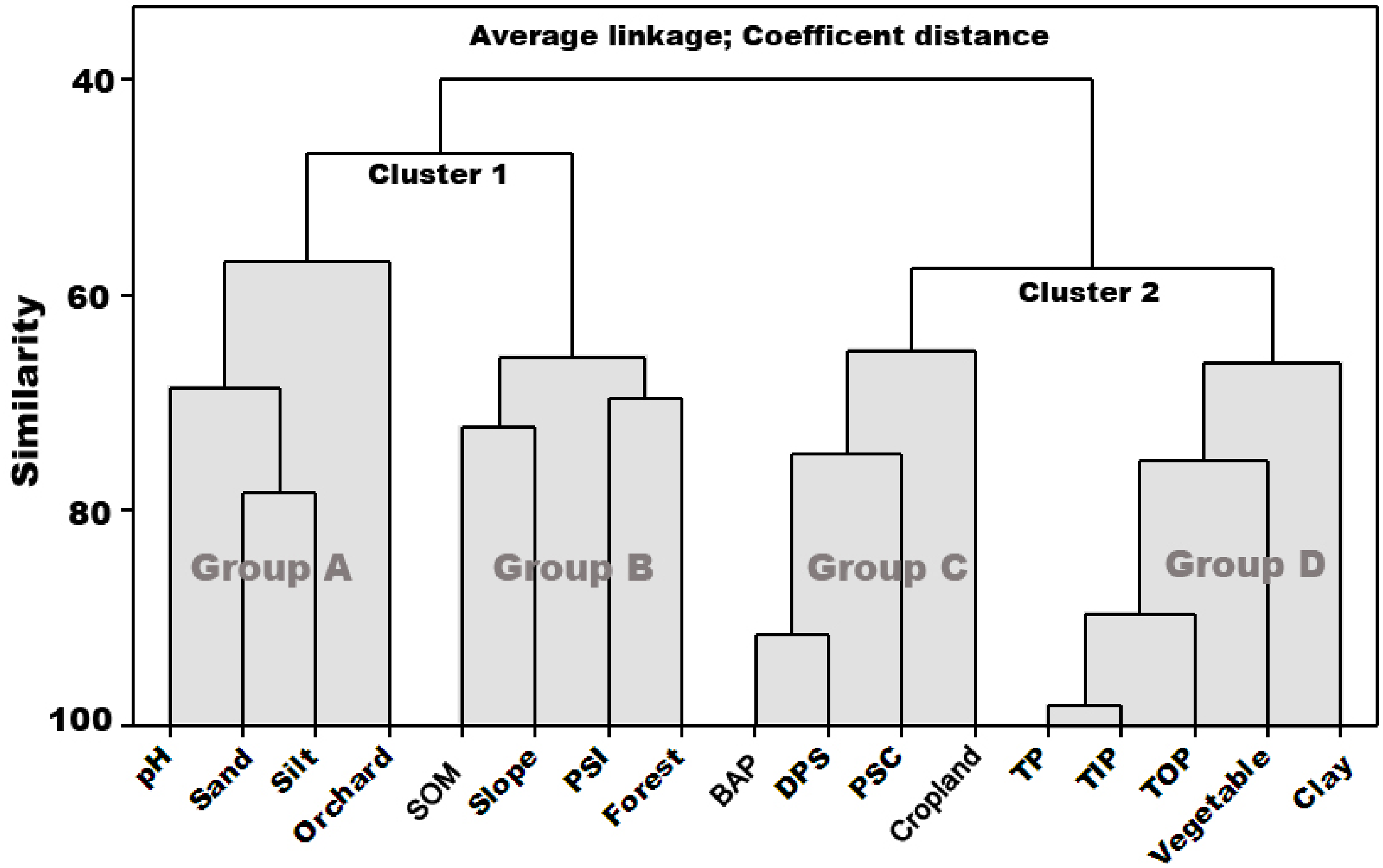
P sorption capacity



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

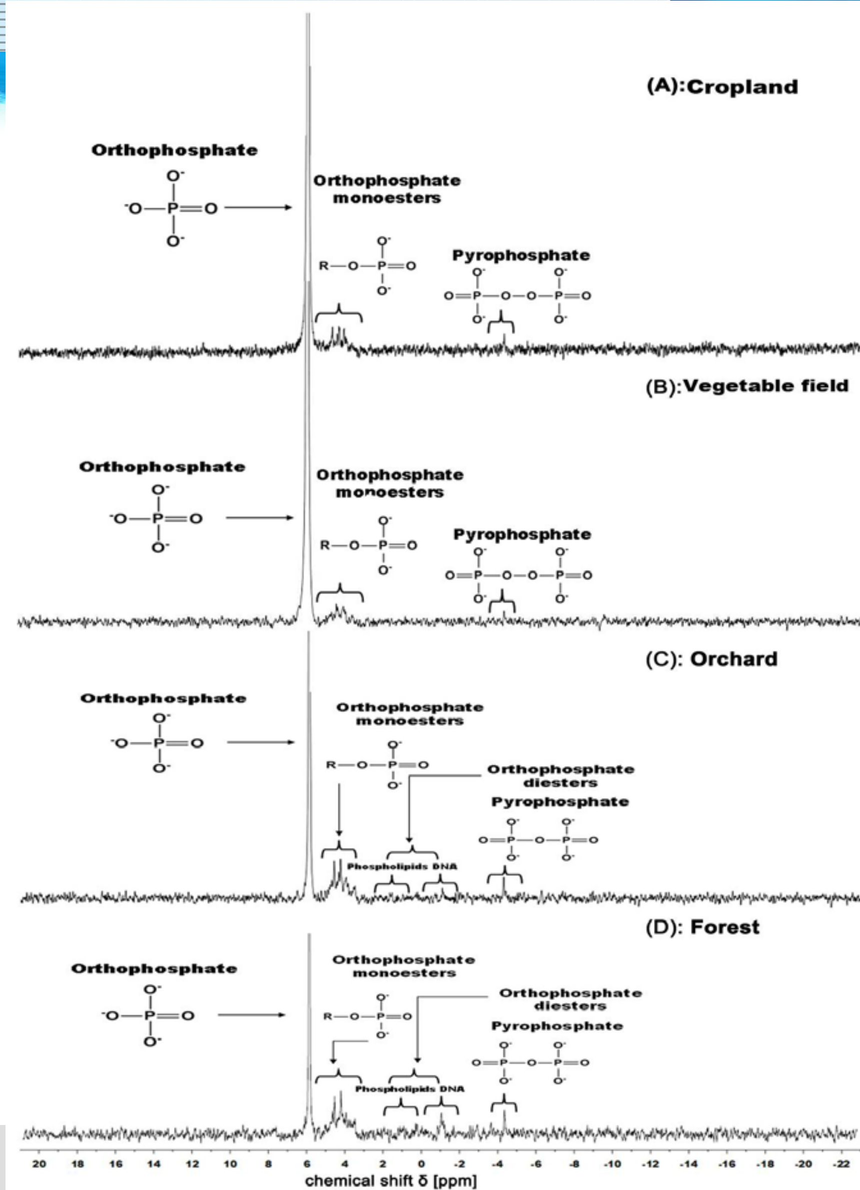
bin.zhou@kjemi.uio.no

Main findings - soil chemistry



bin.zhou@kjemi.uio.no

Main findings - soil chemistry



Main findings - soil chemistry

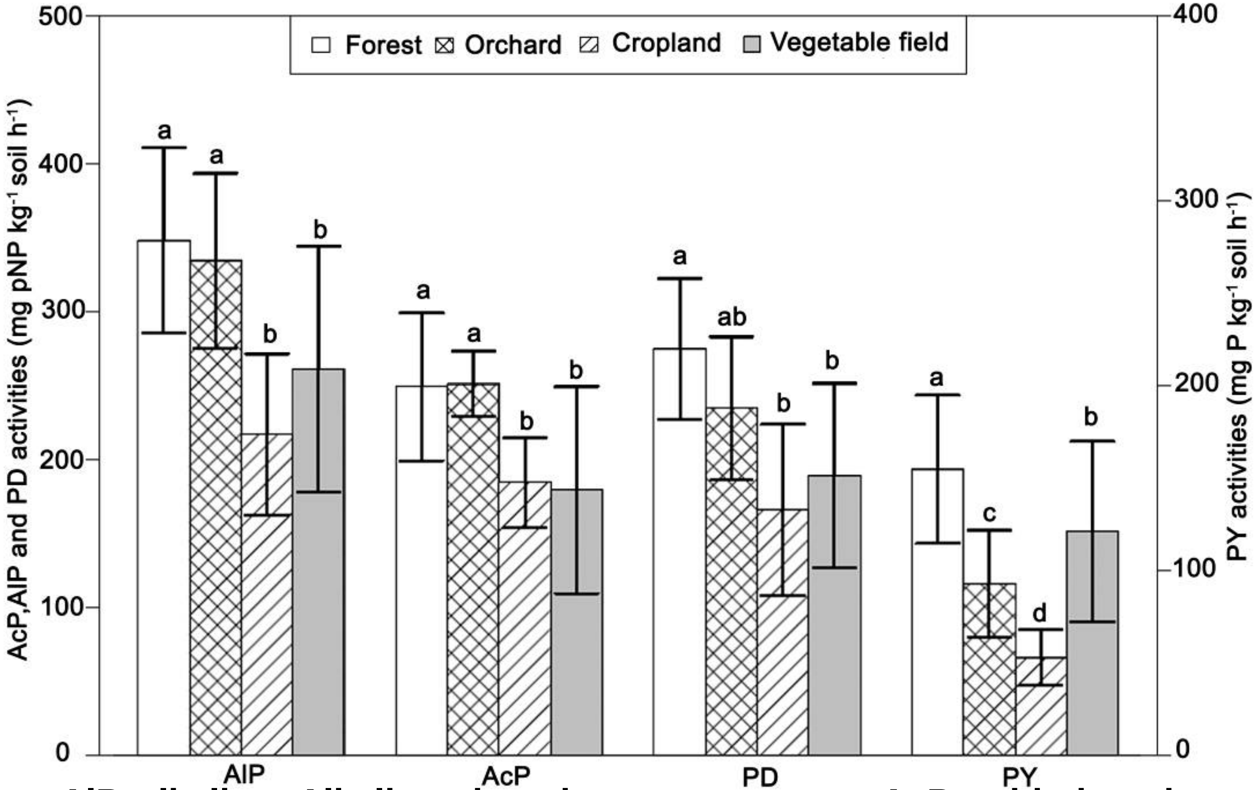
Table

Concentrations (mg P kg^{-1} soil) of different P species, measured using ^{31}P NMR, within different land-use types and their proportions to total P in NaOH and EDTA extracts

Land-use	NE-TP	NMR-P_i			NMR-P_o					
					Monoester-P			Diester-P		
		Ortho-P	Pyro-P	Poly-P	Total monoester-P	Inositol -P: Myo-	Inositol -P: Scyllo-	PL	DNA-P	Phos-P
Forest	155±12a	79±7a (50.7%)	7±0.6b (4.5%)	2.3±0.2ab (1.5%)	63±5a (40.9%)	4.4±0.4 b (2.8%)	2.4[ii] (0.8%)	1.3±0.5[iii] (0.8%)	0.7±0.01 (0.5%)	2.1±0.2 (1.4%)
Orchard	374±15b	287±14b (76.7%)	3±0.5a (0.8%)	1.5±0.1a (0.4%)	80±6c (21.5%)	3.1±0.2ab (0.8%)	3.0[ii] (0.8%)	1.6±0.4 (0.4%)	0.1±0.02 (0.03%)	1.1[ii] (0.3%)
Cropland	409±127c	360±13b (88.1%)	2.9±0.1 a (0.7%)	2.3±0.3ab (0.6%)	39±6bc (9.7%)	5.8±0.3c (1.4%)	2.8[i] (1.2%)	2.5±0.3 (0.9%)	0.4±0.03[iii] (0.2%)	1.4[ii] (0.3%)
Vegetable fields	826±47d	770±43 c (93.3%)	2.9±0.2 a (0.4%)	1.3±0.1a (0.2%)	49±3b (5.9%)	2.5±0.2a (0.3%)	0.9[i] (0.1%)	1±0.4 (0.1%)	0.2±0.01 (0.02%)	1.2±0.05[iii] (0.1%)

■ **The dominant inorganic and organic P species in the soils were orthophosphate and monoester-P, respectively.**

bin.zhou@kjemi.uio.no



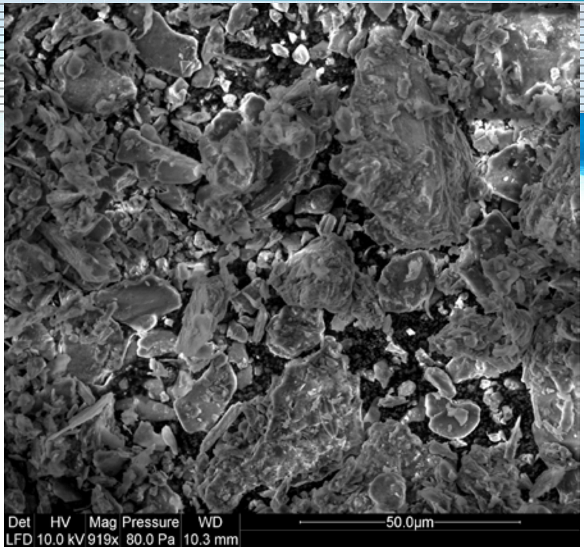
AlP, alkaline :Alkaline phosphomonoesterase; AcP, acid phosphomonoesterases; PD, Phosphodiesterases; Pyrophosphatase;

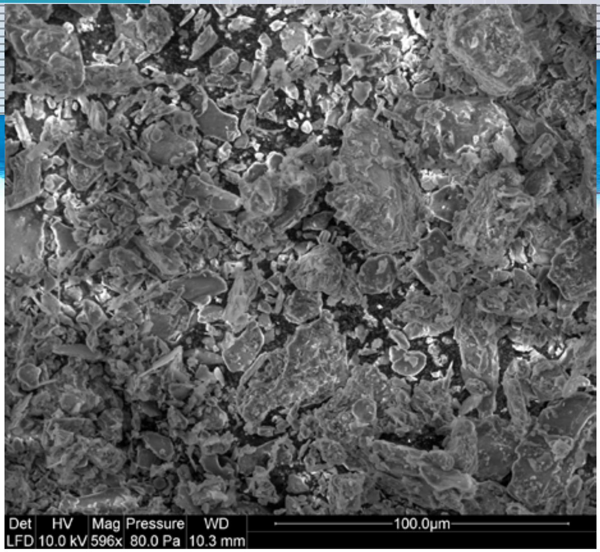
- **Alkaline phosphomonoesterase (AlP) represented the highest activities among the four representative phosphatases**.

- **Orchard soils were found to contain highest levels of monoester P as we ll as high AlP activities, which indicates its strong capacity to produce labi le orthophosphate.**

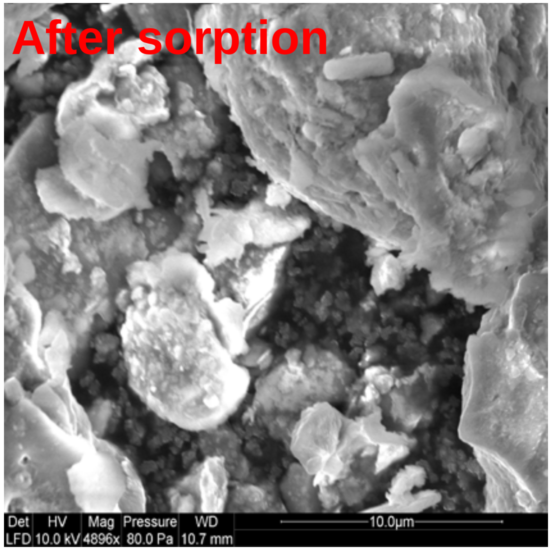
bin.zhou@kjemi.uio.no

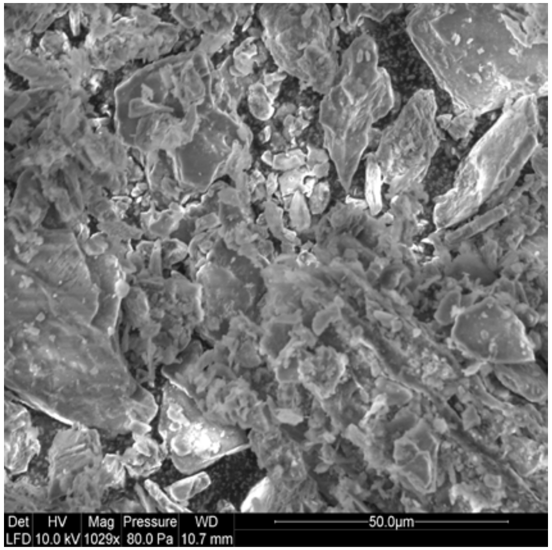
Main findings

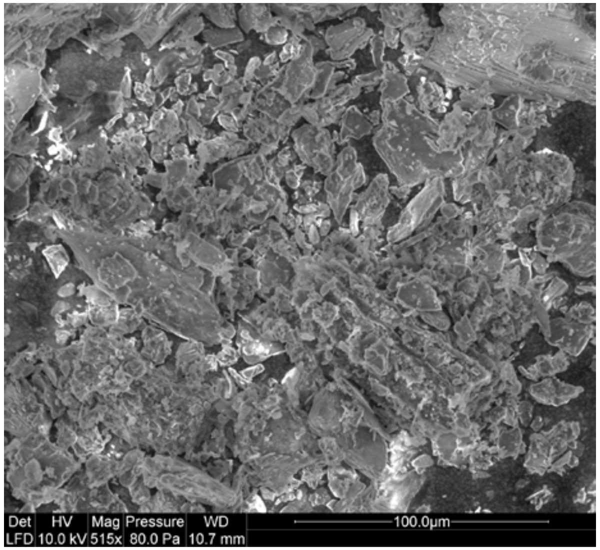




10um **50um** **100um**







bin.zhou@kjemi.uio.no

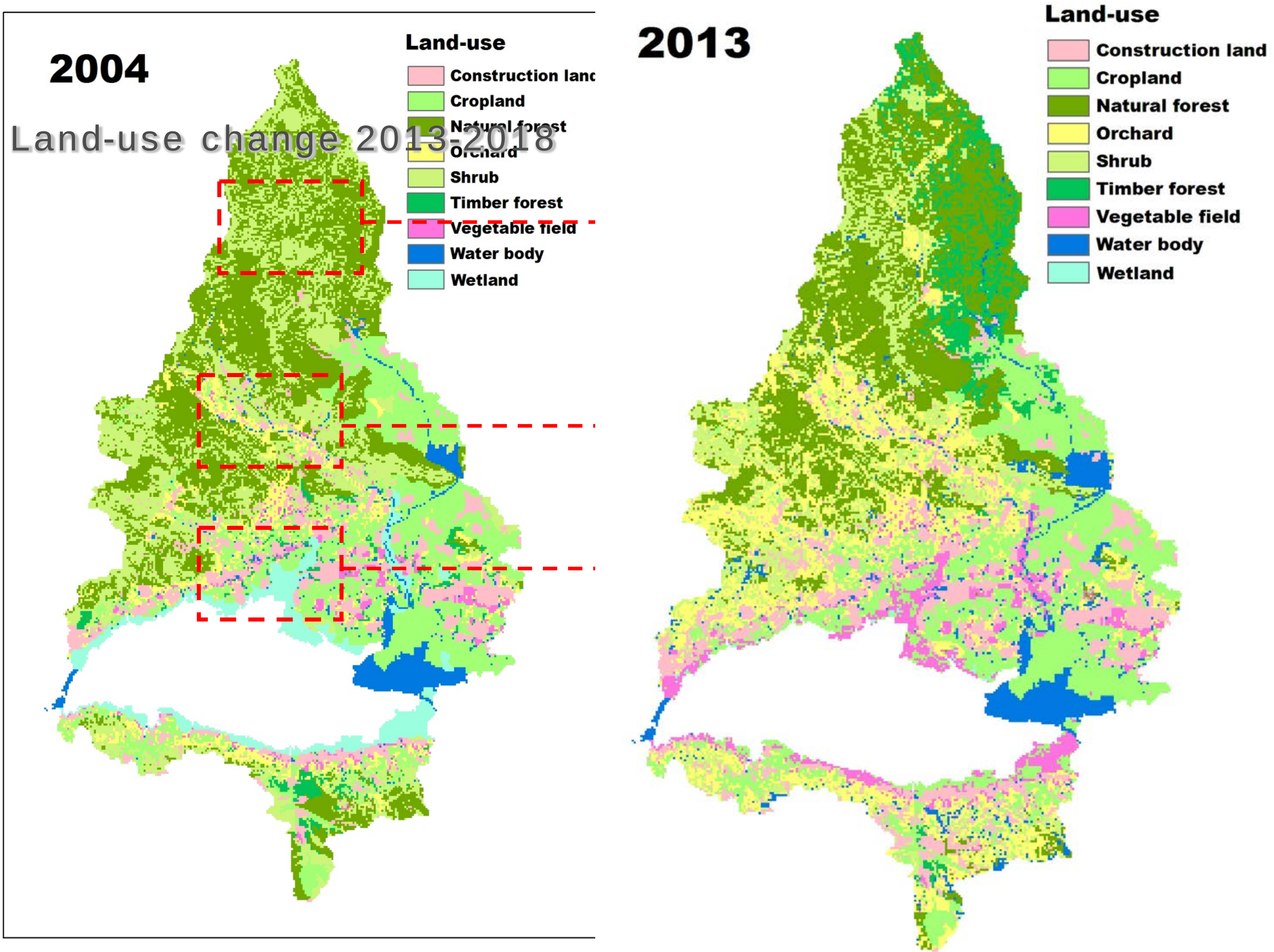
Main findings

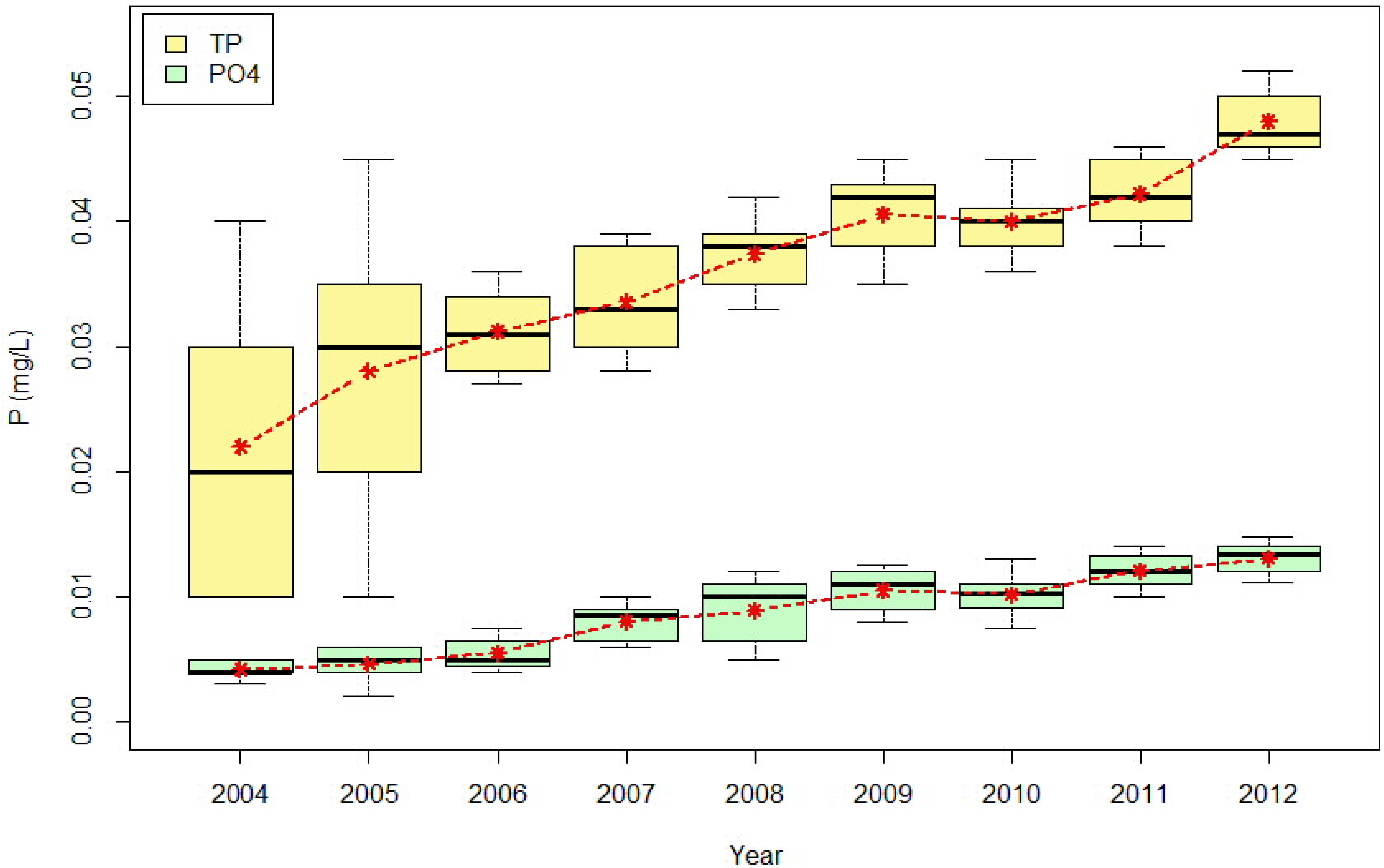
Pore size distribution and special surface area changes

Test samples	Surface area ($m^2.g^{-1}$)	Average pore size (nm)	Pore volume ($cm^3.g^{-1}$)	Micropore (<2nm)%	Mesopore (2-50nm)%	Macropore (>50nm)%
Before sorption	32.87	4.988	0.04099	2.15	33.74	64.11
After sorption	25.77	7.67	0.04942	3.99	71.89	24.12

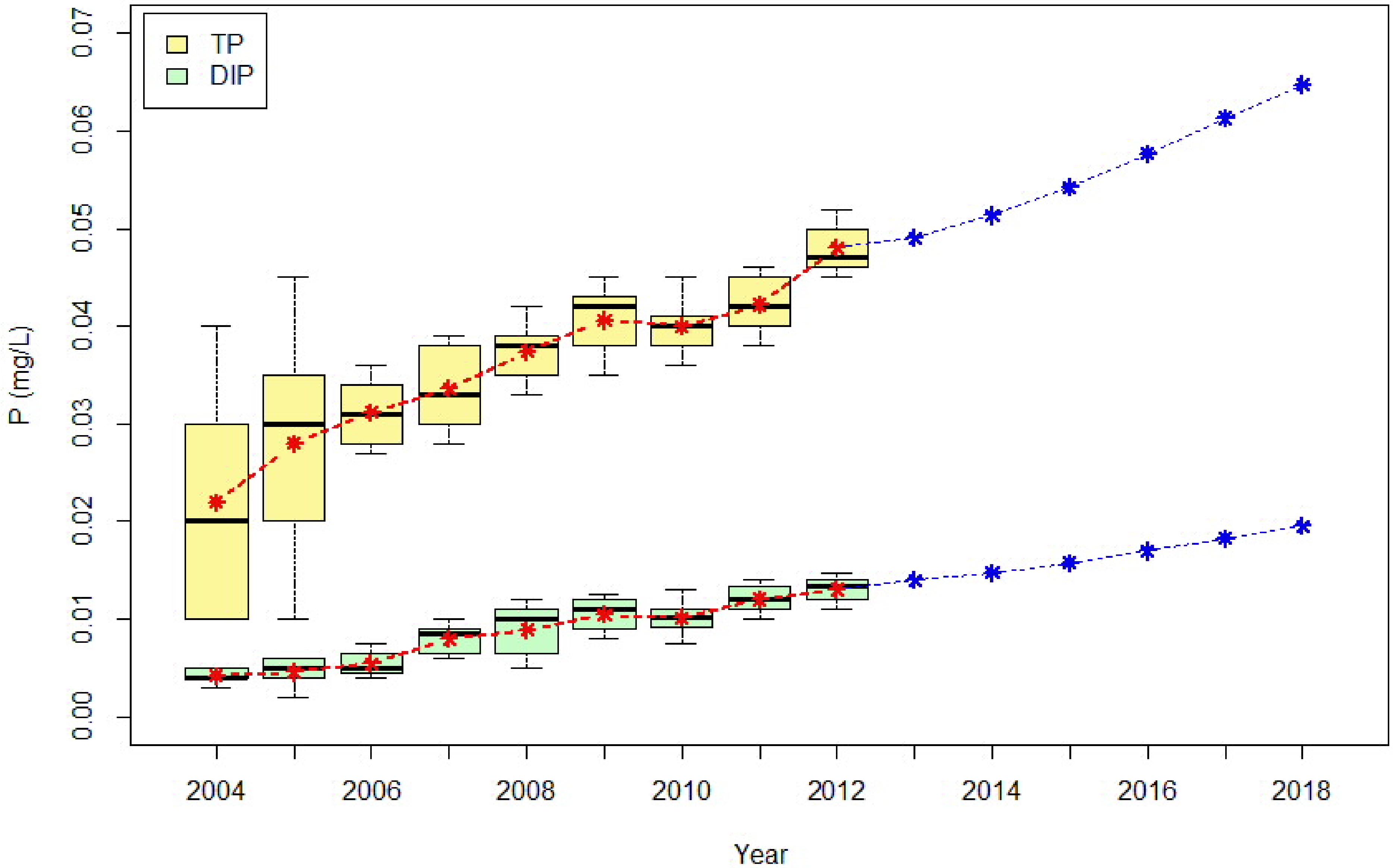
bin.zhou@kjemi.uio.no

Land-use change 2013-2018




TP
PO4
P (mg/L)
0.00
0.01
0.02
0.03
0.04
0.05
2004
2005
2006
2007
2008
2009
2010
2011
2012
Year

Model: L + P + H



TP
DIP
P (mg/L)
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
2004
2006
2008
2010
2012
2014
2016
2018
Year

Paper publishing

SCI paper:

1. **Zhou, B**., Vogt, R. D., Xu, C., Lu, X., Xu, H., Bishnu, J. P. & Zhu, L.: 2014, 'Establishment and Validation of an Amended Phosphorus Index: Refined Phosphorus Loss Assessment of an Agriculture Watershed in Northern China', Water, Air, & Soil Pollution 25, 1-16. DOI: 10.1007/s11270-014-2103-x.
2. **Zhou, B**., Vogt, R. D., Lu, X., Xu, C., Xu, Zhu, L.,Shao, X.,Liu H. & Xing, M.: 2015,'Relative Importance Analysis of a Refined Multi-parameter Phosphorus Index Employed in a Strongly Agriculturally Influenced Watershed', Water, Air, & Soil Pollution. DOI: 10.1007/s11270-014-2218-0
3. **Zhou, B**., Vogt, R. D., Lu, X.,Yang X., Lü C., Zhu, L., Mohr, W. C., Shao, X.,:2015, 'Land use as explanatory factor for potential phosphorus leaching risk, assessed by P indices, 31P-NMR speciation and enzyme activity', Environmental sciecnes: processes & impacts (in press)
4. Xie, Z., He, J., Lü, C., Zhang, R., **Zhou, B**., Mao, H., Song, W., Zhao, W., Hou, D. & Wang, J.: 2014,'Organic carbon fractions and estimation of organic carbon storage in the lake sediments in Inner Mongolia Plateau, China', Environmental Earth Sciences, 1-10. DOI 10.1007/s12665-014-3568-z
5. Hongliang Xu, Chong-yu Xu, **Bin Zhou,** Hua Chen.2014. Entropy theory based multi-criteria resampling of rain gauge networks for hydrological modelling - a case study of humid area in southern China.Journal of Hydrology (Accepted).
6. Xu, H., C.-Y. Xu, N. R. Sælthun, **B. Zhou,** and Y. Xu. Evaluation of reanalysis and satellite-based precipitation datasets in driving hydrological models in a humid region of Southern China. Stochastic Environmental Research and Risk Assessment:1-18.

EI paper:

Xu, H., Xu, C.-Y., **Zhou, B.** & Singh, v.: 2013, 'Modelling runoff response to land-use change using an integrated approach in Xiangjiang River basin, China', IAHS-AISH publication, 390-396.

Two more papers have been preparing...

bin.zhou@kjemi.uio.no

Thank you for your attention !

Takk for oppmerksomheten!

谢谢关注！

bin.zhou@kjemi.uio.no