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INNOVATION LAB FOR
Small Scale Irrigation

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Collaborative Research on Sustainable Intensification

Irrigation and agriculture development in Africa: Impact on water quality and ecosystem health in the Ethiopian highlands

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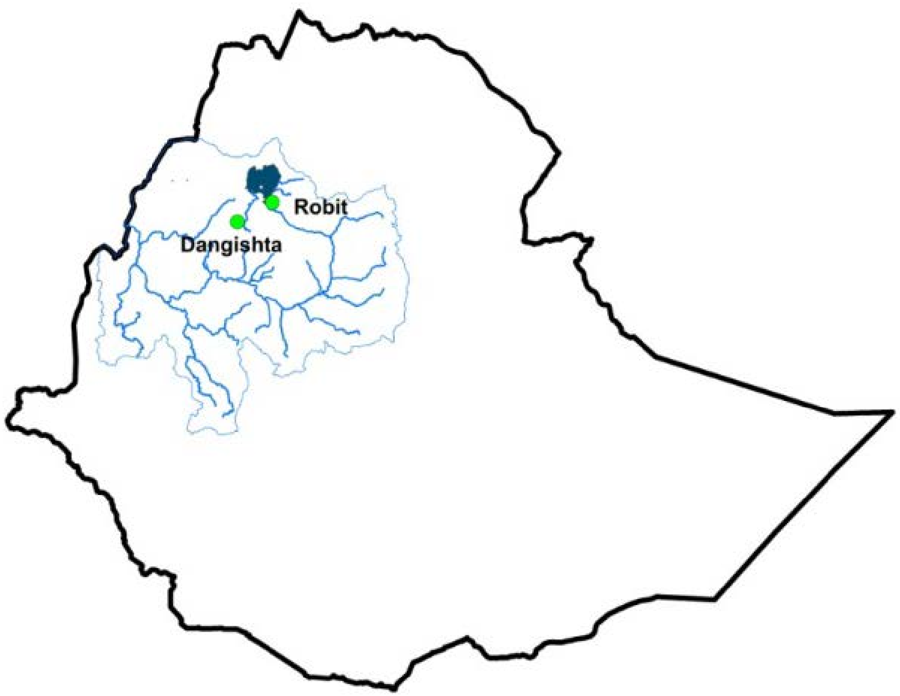
Study aim

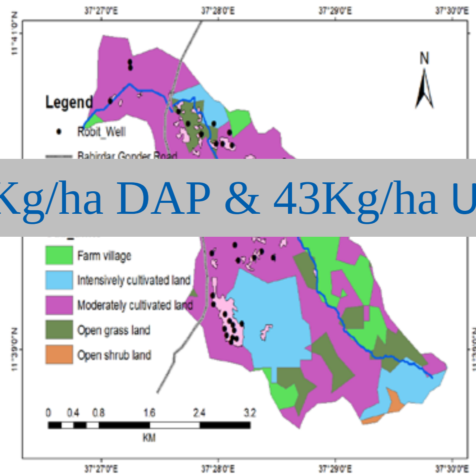
- Purpose: Evaluate the effect of intensification on water quality: shallow groundwater, streams, lake water bodies & biomass
- Location: Amhara region, Ethiopia



Different intensification levels & topography

Robit (intensified)

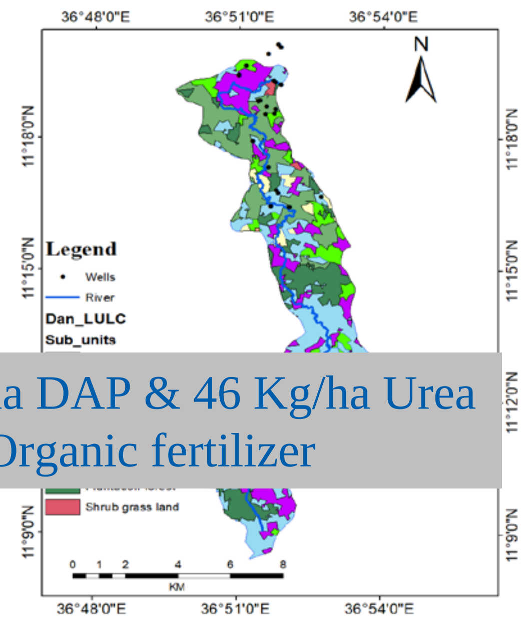
~1000 ha



72 Kg/ha DAP & 43Kg/ha Urea

Dangishta (less intensified)

~5700 ha



90 Kg/ha DAP & 46 Kg/ha Urea

0.4 m^3 Organic fertilizer

- Agricultural land use: 80% (Robit) and 60% (Dangila)
- Slope class: 0-43% (Robit) and 0-28% (Dangila)
- Irrigation in Robit > Dangila
- endosulfan (α+β) 256ml/ha

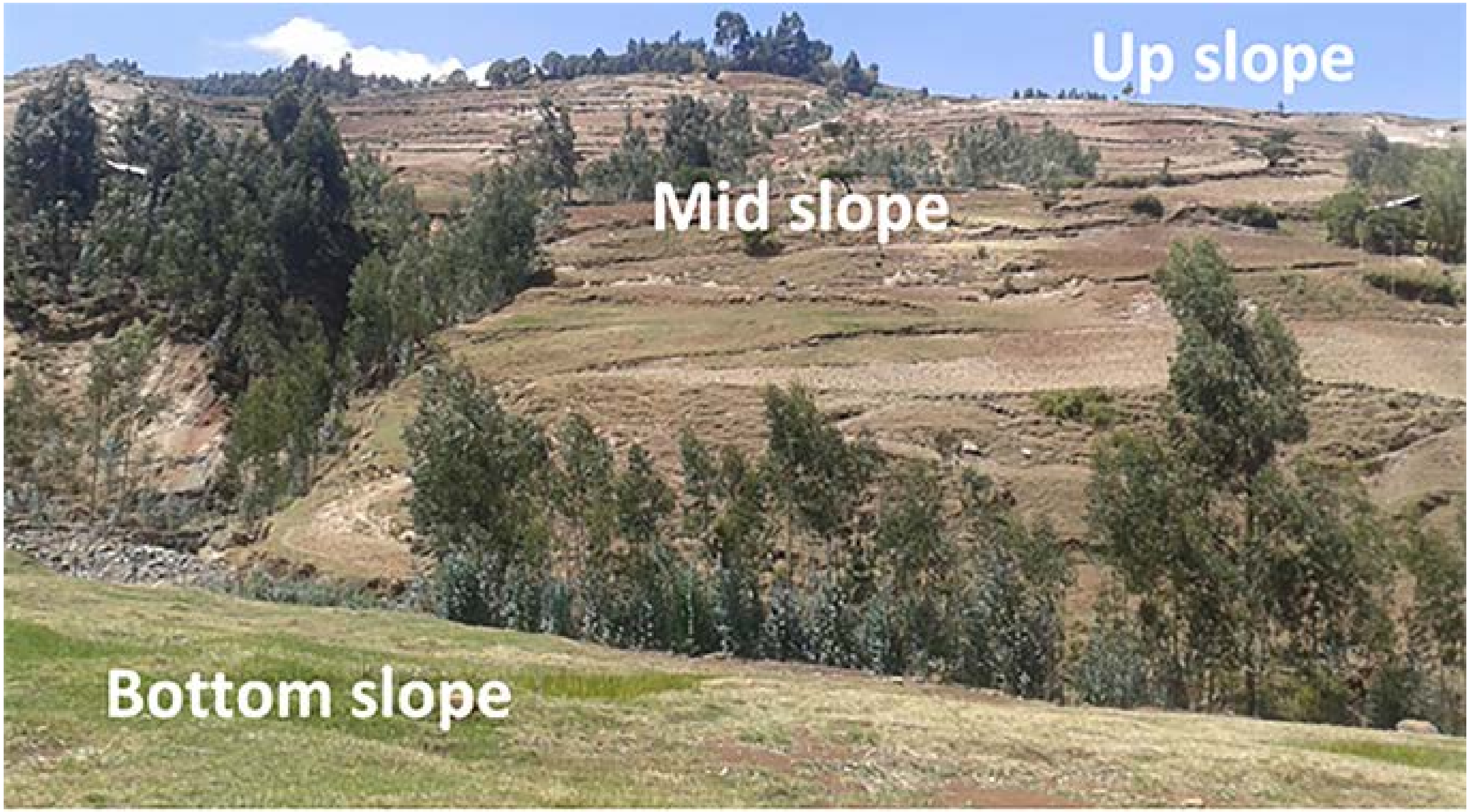
Soil characteristics

Mean values ±SD of soil chemical parameters from different land uses

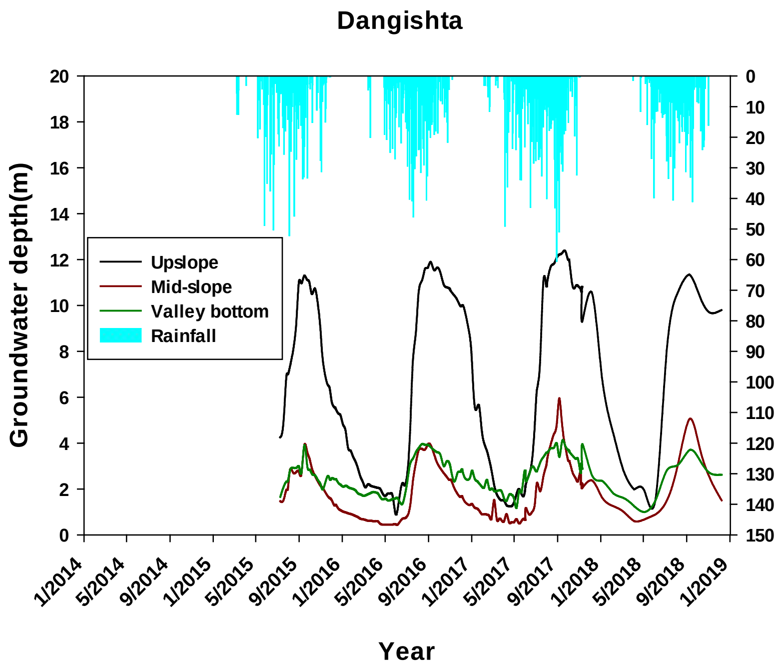
Watershed	land use	pH	OM(%)	TN(%)	Avl.P(mg/l)
Robit Bata	Farm land	6.0±.18	1.9±.8	0.09±.04	7.7±1.9
	Grazing land	5.7±.18	3.8±.82	0.188±.04	4.7±1
	Forest	5.6±.36	3.5±1.8	0.17±.09	5.4±1.7
	Khat irrig.	5.8±.13	3.2±1	0.16±.05	9.2±4.4
Dangishta	Farm land	5.1±.18	3.2±.6	0.16±.03	15.8±4
	Grazing land	4.8±.15	4.5±.5	0.23±.02	9.5±2
	Forest	5.1±.05	3.6±.5	0.18±.02	11.6±1.7

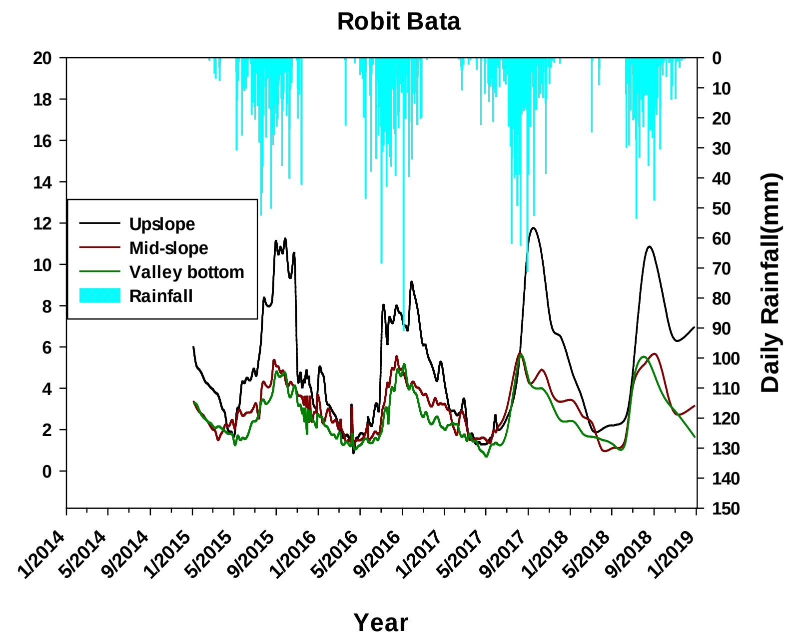
- Soil pH values were higher in Robit Bata than Dangishta
- Soil OM , TN and available P (Robit < Dangila)

Typical landscape



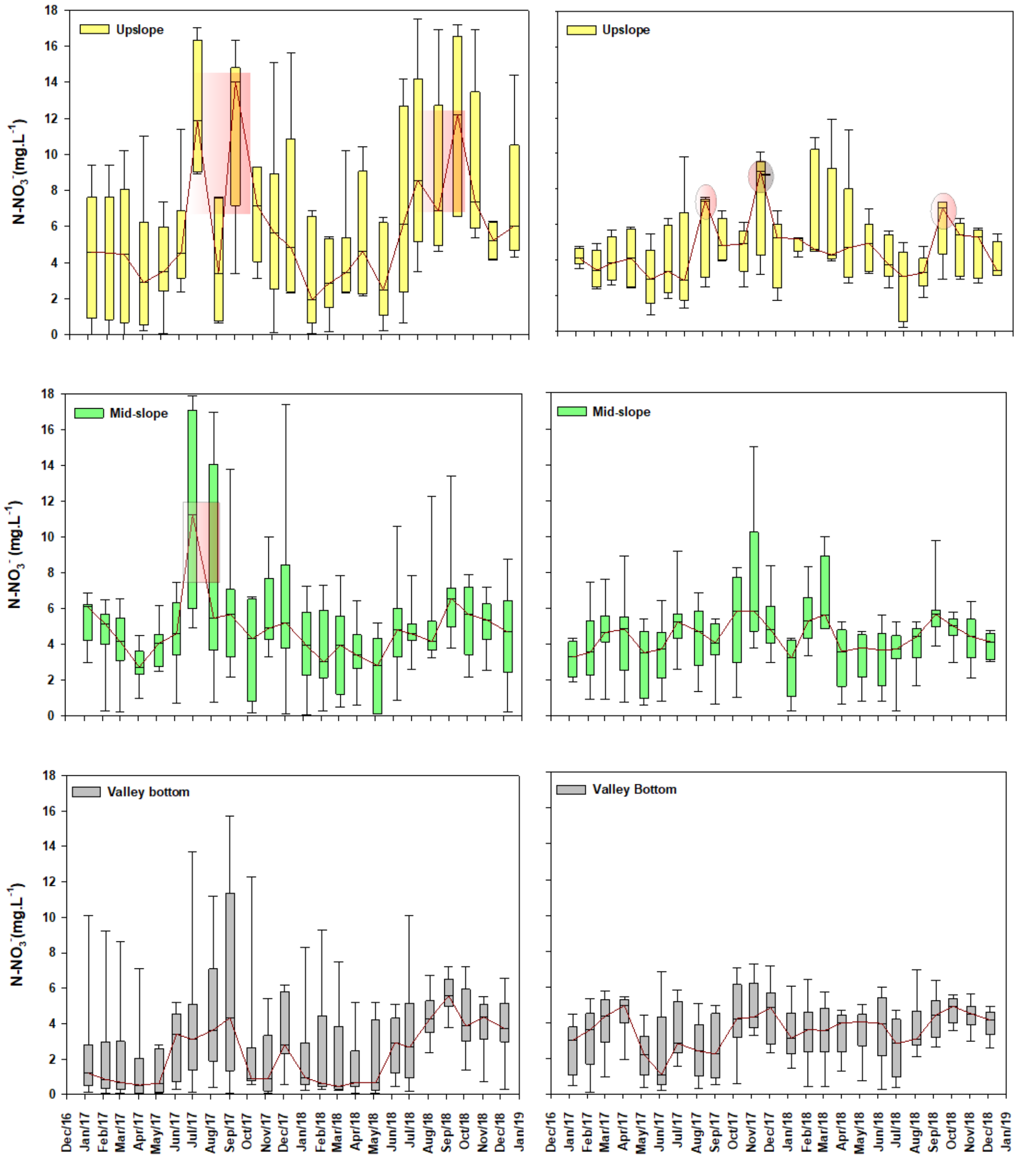
Groundwater Level Variation Overtime





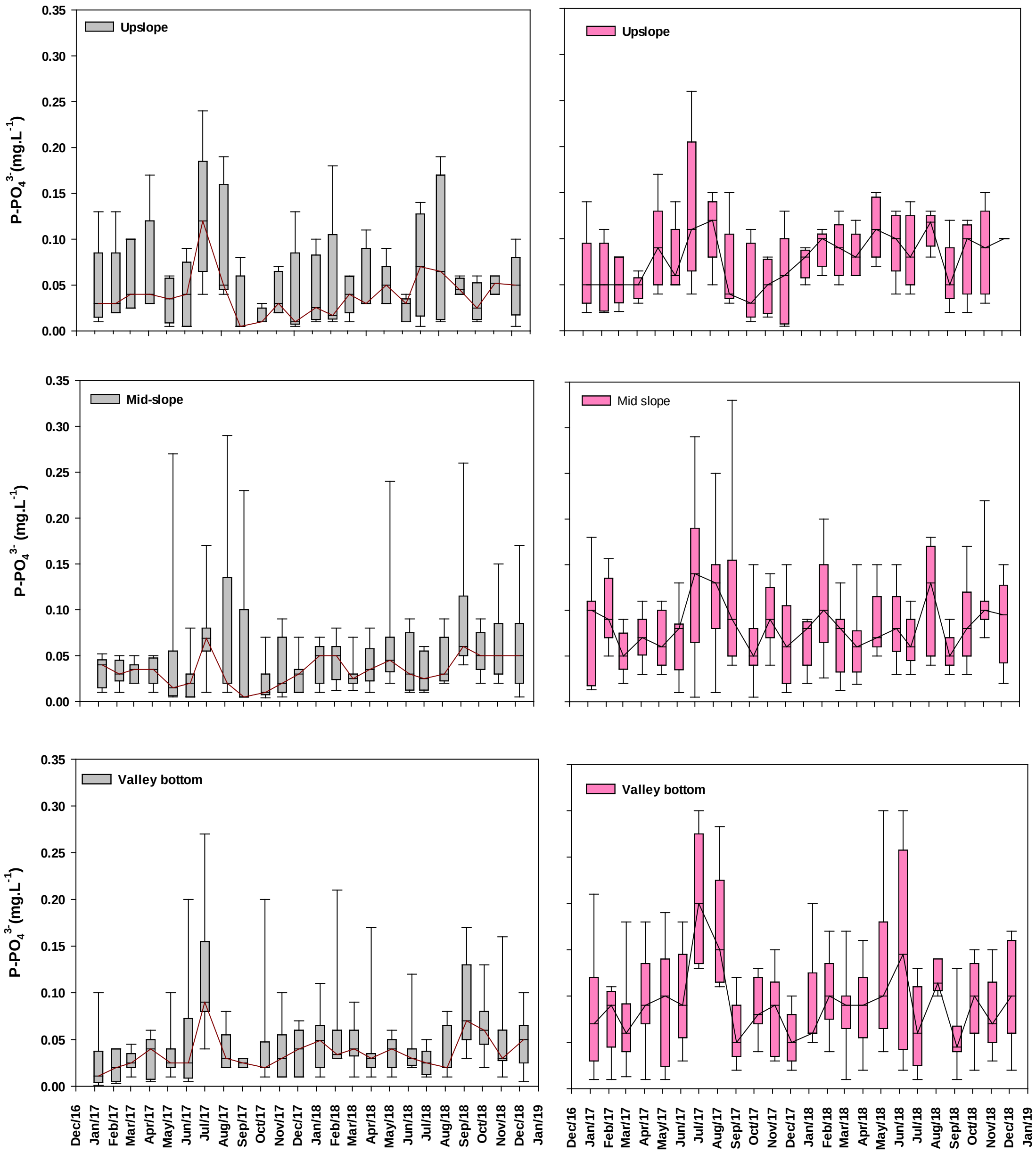
Groundwater table variations vary across the two watersheds due to rainfall distribution and irrigation level

Groundwater Nitrate



- Higher level NO_3^- was observed during rainy season
- Irrigation months (Oct-Dec) higher NO_3^- compared to dry non-cropping period (Jan-May)
- NO_3^- signficantly lower in valley bottom and lowest in Dangila (***P<0.001***)
- Rainy season: risk of levels above EPA drinking guidelines (**10 mg l^{-1}**)

Groundwater Phosphorus



- Rainfed cropping season PO_4^{3-} was significantly high in both watersheds (***P=.018***)
- Higher concentration levels in Robit likely related to relase of PO_4^{3-} from soil in the landscape because of low soil OM (Robit < Dangila in OM)

Processes control contaminants in GW

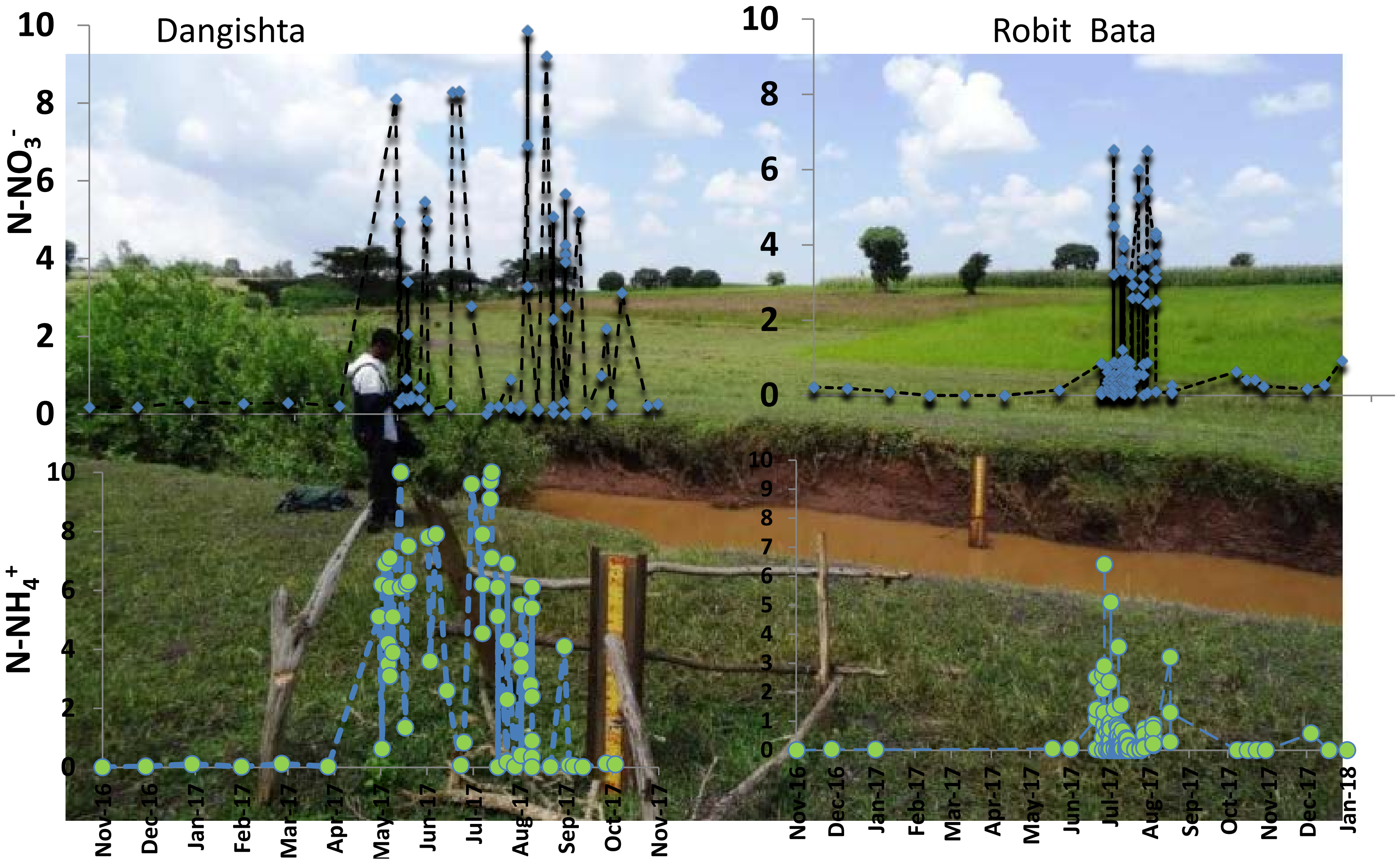
$$N\text{-}NO_3^- = .5 + (.2Cl^-) + (-.317Cl^-/N\text{-}NO_3^-) + (.156K^+) + (.232\Delta H)$$

$$P\text{-}PO_4^{3-} = .027 + (-.006Cl^-) + (.008\Delta H)$$

ΔH=monthly groundwater table level fluctuation (m)

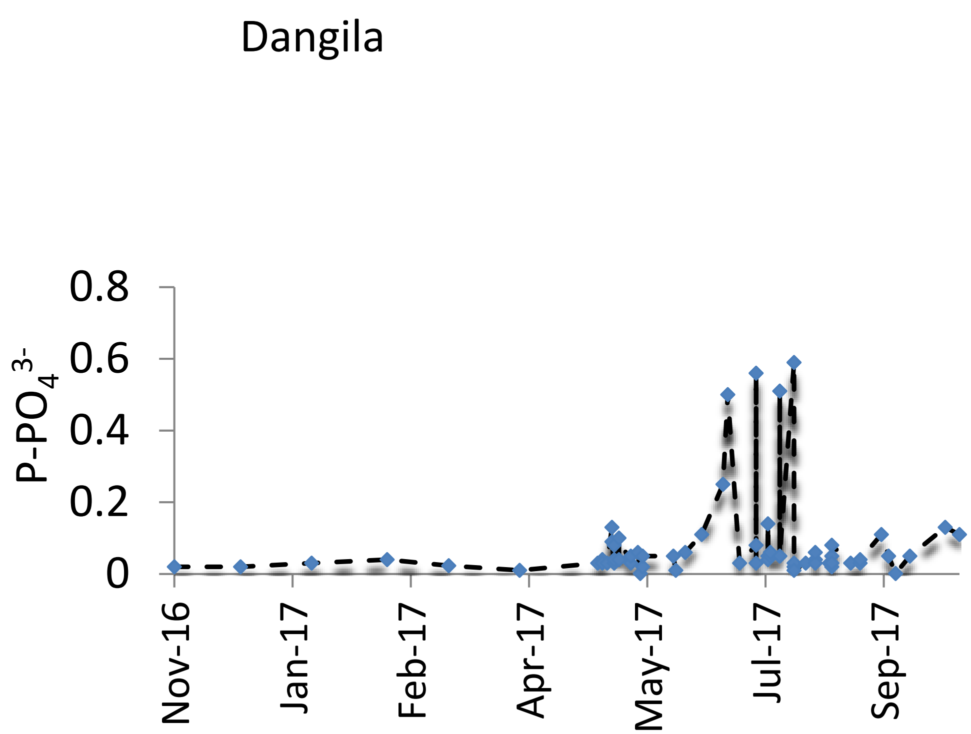
- MLR analysis produced statistically significant models(***P<05***)
- Cloride and ΔH positively contribute to PO_4^{3-} in both watersheds
- Chloride, potassium, and fluctuation in groundwater table (ΔH) positive contribute to N-NO3- due to dissimilation and dinitrification

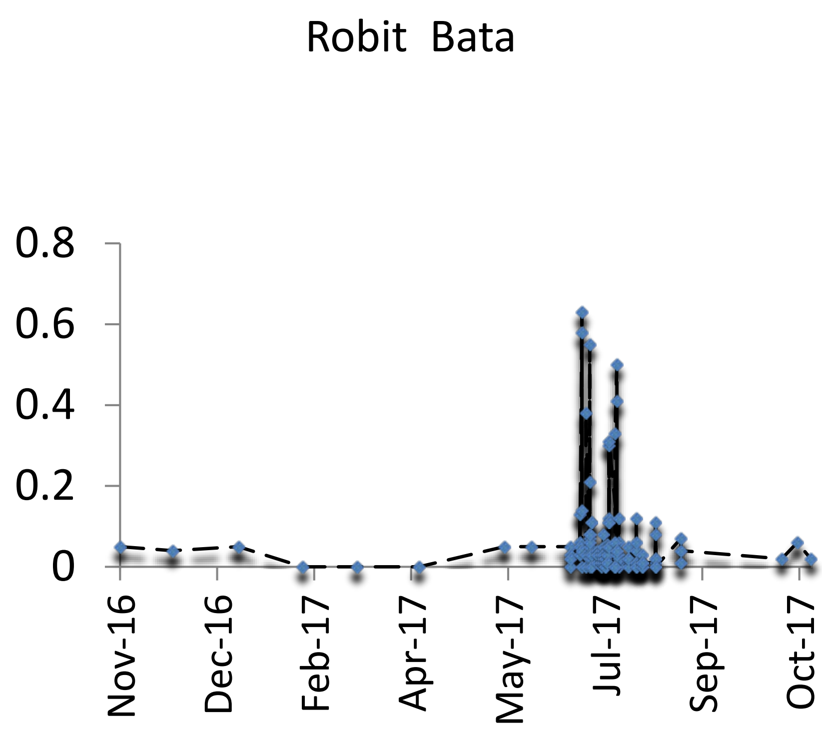
Streams: Nitrate and Ammonium



- Both nitrate and ammonia were dominant in stream during rainy period
- Only nitrate was high during dry period.

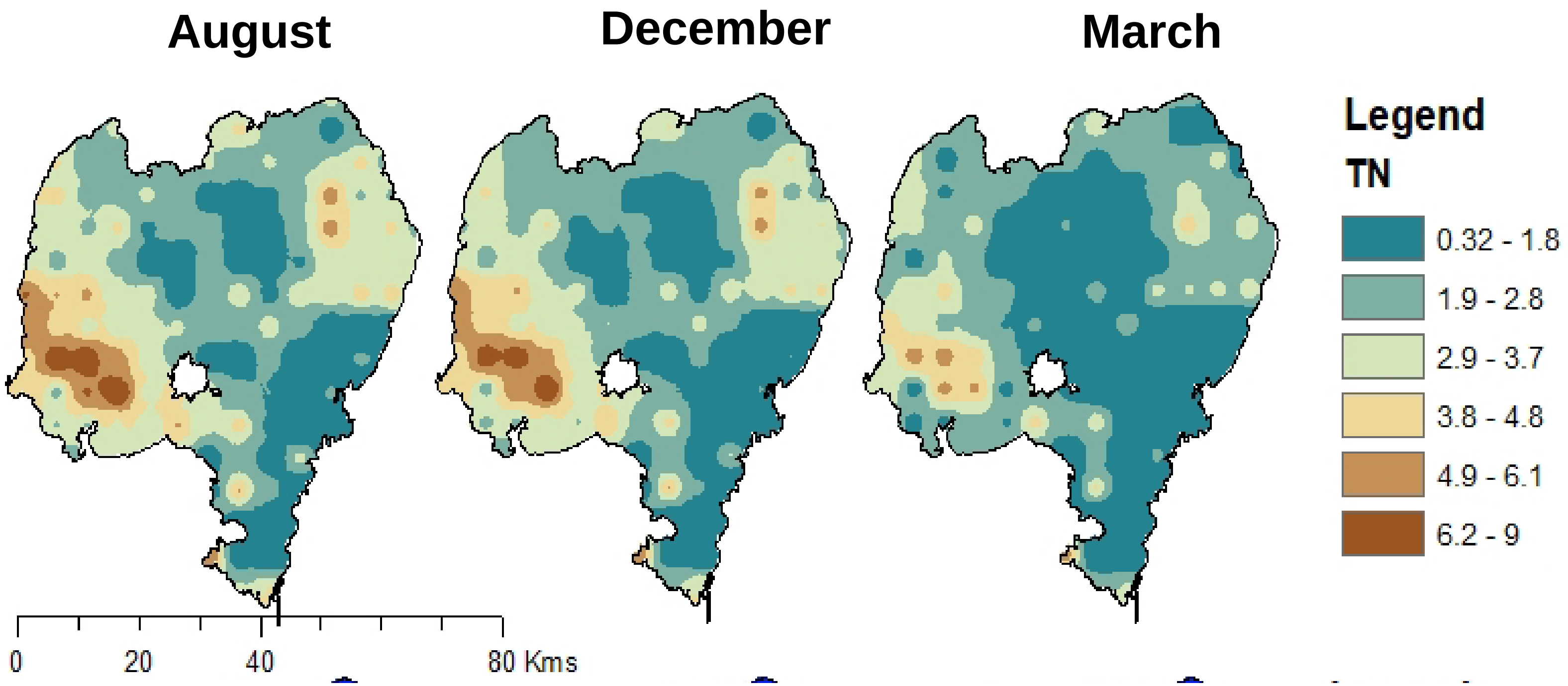
Streams : Phosphorus





- Dissolved P was high during rainy period in high-flow in the order of 0.6 mg $P\text{-}PO_4^{3-}.L^{-1}$

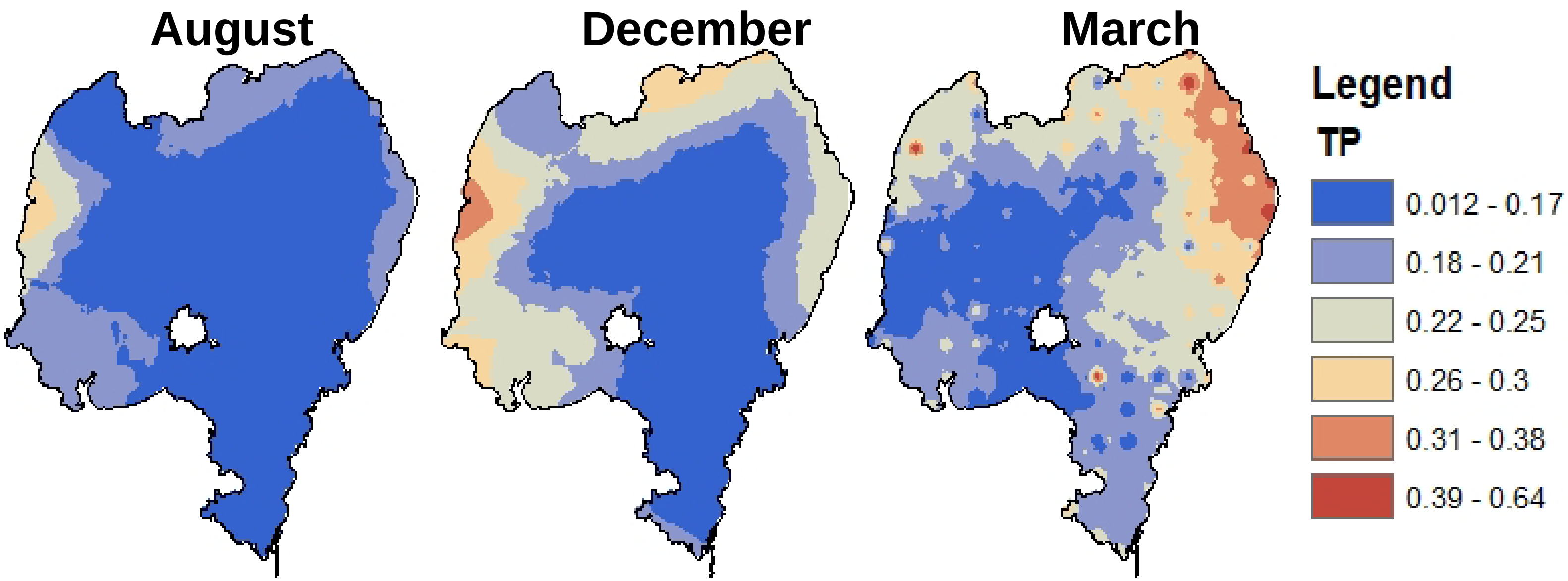
Total Nitrogen: spatial



Ateka et al. (draft)

- Concentration of TN is generally lower than WHO permissible limit
- Decrease in load and increase in biological activity drive lower TN concentration.

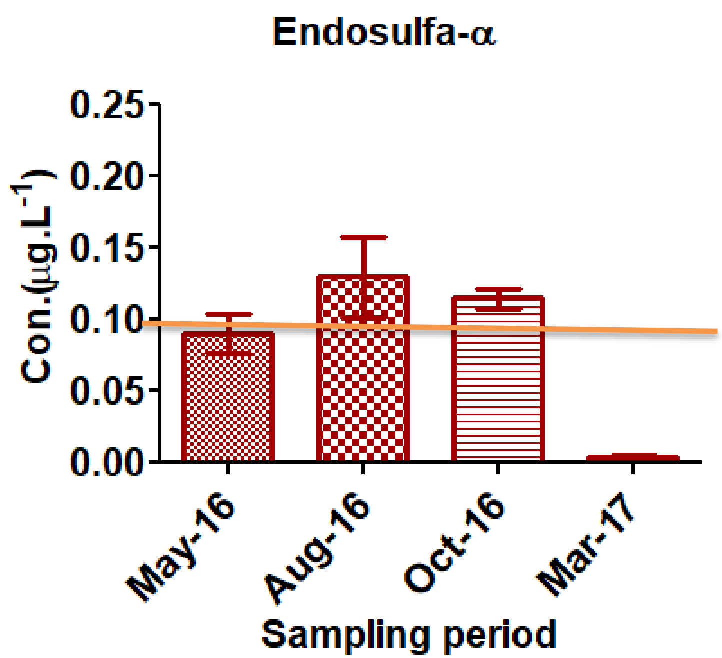
Total Phosphorus: spatial

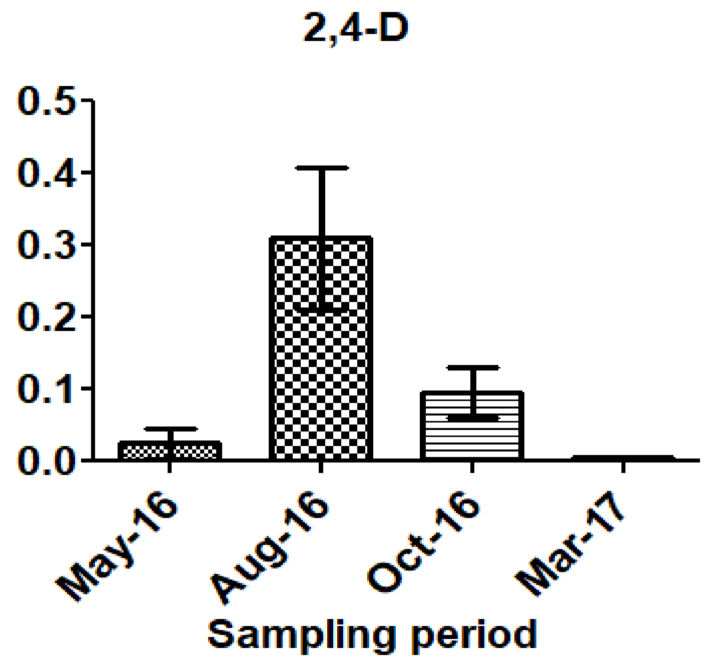


Ateka et al. (draft)

- Largest freshwater body (Lake Tana) started to exceed the 0.2 mg/L of P - minimum level for eutrophication
- Increasing trend in TP from Aug 2016 to Mar 2017 could be with high internal loading

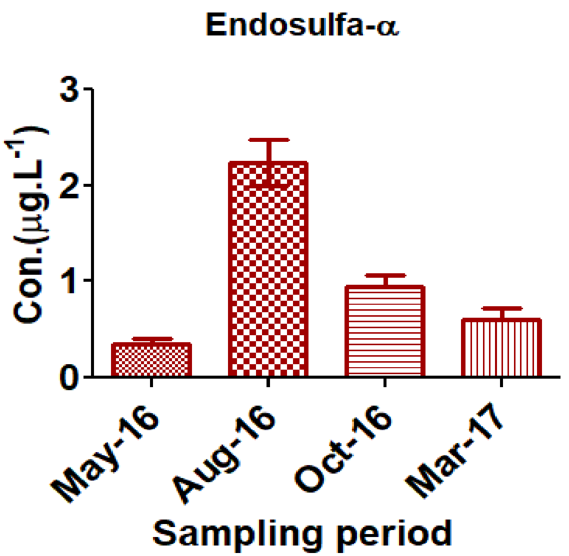
Pesticides in groundwater

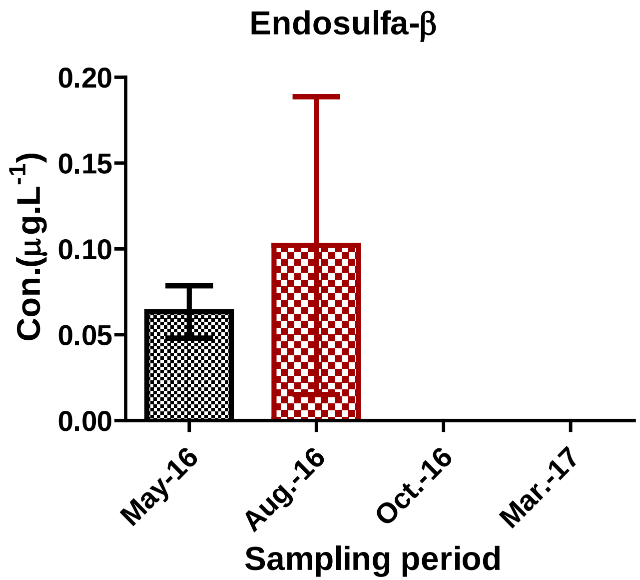


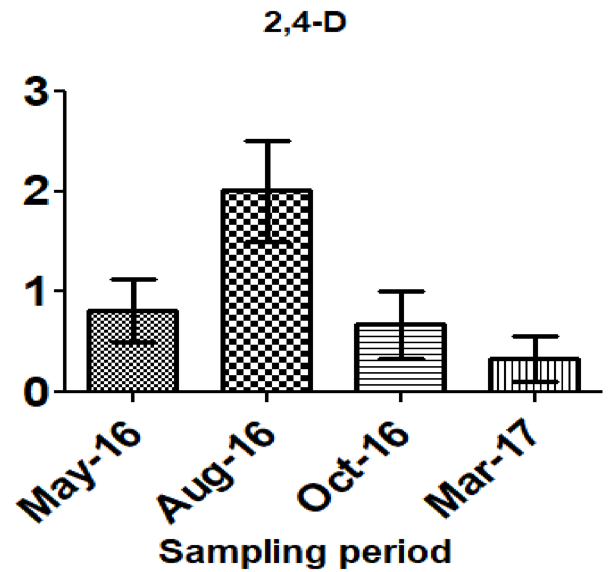


- Endosulfa-α concentrations were high in rainy period (August) and irrigation (October) period. The values **exceeded MAL**- value of EU 0.1 µg L^{-1}
- Endosulfa-β in groundwater was not detected during study period

Pesticides in Stream

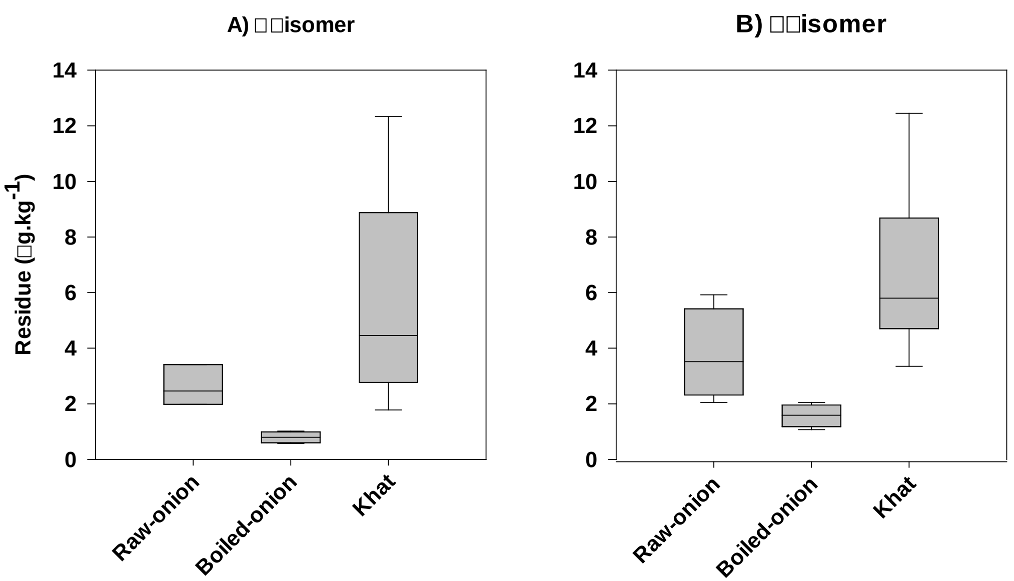






- Endosulfa-α concentrations were high during rainy period (August) and irrigation (October) period. The values **exceeded MAL-** value of EU 0.1 µg L^{-1}
- Endosulfa-β and 2,4-D in streamflow were not exceeded EU MAL in study period

Residue levels in onion and khat biomass



The EU pesticides regulation for α- and β-endosulfan residue in bulbs and vegetables recommended a tolerance level of 100 $\mu g.kg^{-1}$

Key messages for sustainable development

- ILSSI project provided evidence for critical institutional changes, guidelines and monitoring mechanisms to regulate agrochemical use and occurance in water bodies
- Increase smallholder awarness on the impact of agrochemicals on water quality and human health needed
- Target and promote intensified SSI in suitable areas through evidence-base on agriculture-water-environment-health system
- Reverse degradation and rehabilitate watersheds (river basins) for improved SSI
- Link watershed management with irrigation

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Thank you

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