Comparative Assessment of Irrigation Water Quality in Sri Lanka's Tank-Cascade and Mahaweli Irrigation Schemes

Thushara Gunda and George M. Hornberger

Civil and Environmental Engineering and Vanderbilt Institute for Energy and Environment

Vanderbilt University, Nashville, TN

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Background

- Sri Lankans have two irrigation schemes:
  - Small tank-cascade scheme
  - Mahaweli Authority of Sri Lanka (MASL) irrigation scheme with reservoirs and canals
- Dissolved organic carbon (DOC) is a constituent of interest, but DOC analyzer is not available in-country
- Fluorescence of chromatic dissolved organic matter (FDOM) and DOC have a robust catchment-specific linear relationship [1]
- FDOM can be measured using a portable, handheld Turner meter (Figure 1)

Figure 1. Portable, handheld Turner FDOM meter

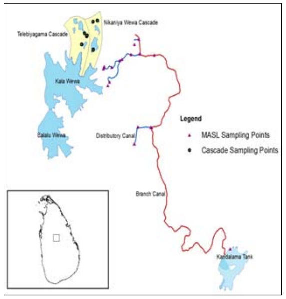

Figure 2. Sri Lanka water sampling sites

Research Questions

- How does FDOM vary spatially within two irrigation schemes?
- Does spatial variability of FDOM preclude its use as a proxy for DOC in Sri Lanka?

Methods

- Cascade and MASL sites near Kalawewa were sampled during Summer 2013 (Figure 2)
- 30 surface water and groundwater samples were collected (Figure 3) and analyzed for:
  - pH, temperature, and conductivity using a Hach HQ40d
  - FDOM and turbidity using a handheld Turner meter
  - nitrate and ammonia using colorimetric methods
- Prior to investing resources to establish a site-specific FDOM-DOC relationship in Sri Lanka, spatial variability in FDOM and DOC were initially studied within the Harpeth watershed (agricultural Tennessee watershed) during Fall 2013 (Figure 4)
- Nine surface water samples were collected in the Harpeth and analyzed for:
  - pH, temperature, conductivity, and oxidation reduction potential using a YSI Pro probe
  - FDOM and turbidity using a handheld Turner meter
  - DOC using a TOC Analyzer
- Four additional samples were collected in one location over the course of a day

Figure 3. Sampling groundwater in Sri Lanka

Figure 4. Harpeth, TN water sampling sites

Results

Table 1. Water quality comparison in Sri Lankan irrigation schemes

	Cascades	Cascades vs. MASL	MASL
pH	Average SW : 7.58 (7.35-7.83) GW: 7.36 No consistent evolution in pH over space	Similar range of pH in both systems pH of water from paddy fields is ~8	Average SW: 7.93 (7.42-8.40) Average GW: 7.05 (6.65-7.50) Steady increase in pH from main canal to fields
Conductivity (µs/cm)	Average SW: 443 µs/cm (207-764) GW: 1597 µs/cm Increase in conductivity downstream	Conductivity is greater in cascade systems	Average SW: 223 µs/cm (220-224) Average GW: 393 µs/cm (217-709) Little change in conductivity over space
FDOM (ppb)	Average SW: 157 ppb (99-204) GW: 30 ppb Steady increase in FDOM downstream of tanks	Cascade SW had greater FDOM Paddy water had higher FDOM in both systems Groundwater had much lower FDOM	Average SW: 58 ppb (52-66) Average GW: 17 ppb (14-21) Slight increase in FDOM downstream
Turbidity (NTU)	Average SW: 11 NTU (3-16) GW: 1 NTU No consistent evolution in turbidity over space	Similar range of turbidity in both systems Turbidity of groundwater is much lower	Average SW: 11 NTU (6-22) Average GW: 4 NTU (1-9) No consistent evolution in turbidity over space
Nitrate (mg/L)	Average SW: 0.2 mg/L (0-0.4) GW: 0.02 mg/L Only upstream samples had detectable concentrations	Most water samples were non-detect High SW nitrate concentrations in cascades were comparable to GW sample in MASL	Average SW: 0.01 mg/L (0-0.05) GW: 0.31 mg/L No consistent evolution in nitrate over space
Ammonia (mg/L)	Average SW: 0.1 mg/L (0-0.2) GW: 0.04 mg/L Only upstream samples had detectable concentrations	Cascade SW samples had higher ammonia concentrations Ammonia concentration of paddy water samples is ~0.07 mg/L	Average SW: 0 mg/L (0-0) Average GW: 0 mg/L (0-0) Only paddy water samples had detectable concentrations

SW – surface water, GW - groundwater

- Greater variability in conductivity and FDOM was present in the surface water samples from the cascade study sites than the surface water samples collected from the MASL study sites (Figure 5)
- FDOM increased downstream in all study areas: cascades, MASL, and Harpeth watershed (Table 1)
- Principal component analysis was used to compare variance between FDOM and other water quality parameters
  - DOC explained the variance in the FDOM (Harpeth samples)
  - When DOC data are absent, conductivity and turbidity explained the variance in FDOM (both Harpeth and Sri Lanka samples)
- Variability in FDOM is two orders of magnitude greater across space than across time (Figure 6)

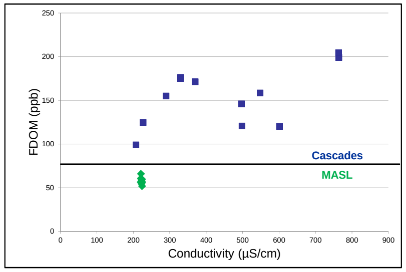

Figure 5. Conductivity and FDOM concentrations in Sri Lanka water samples: cascade samples have higher conductivity and FDOM than MASL samples

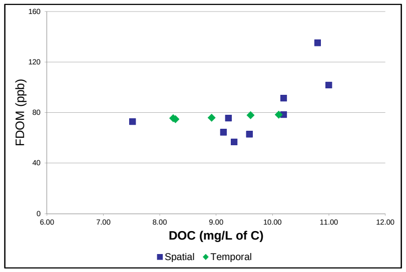

Figure 6. FDOM-DOC plots of Harpeth water samples: magnitude of spatial variation in FDOM is two orders of magnitude greater than temporal variation in FDOM over the course of a day

Discussion

- MASL canals were predominantly lined with concrete in the study area, which might explain limited variations in conductivity and FDOM downstream of reservoirs relative to tanks in cascade systems
- Due to limited variation in FDOM within MASL, a single site-specific relationship might be sufficient to establish FDOM as a proxy for DOC for the entire scheme
- In cascade systems, multiple site-specific FDOM-DOC relationships will need to be established to account for the greater spatial variability in FDOM
- Evolutions in water quality patterns imply a need for different requirements for water quality data collection and eventually management approaches to maximize agricultural yields

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References

[1] Spencer, R. G. M., K. D. Butler, and G. R. Aiken (2012), Dissolved organic carbon and chromophoric dissolved organic matter properties of rivers in the USA, *JGR*, *117*(G3), G03001, doi:10.1029/2011JG001928.