Water quality in urbanized alpine catchments of Central Asia – what happens after the ice?

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**Photo: Ulken Almaty River, May and August 2019. Distance between 2 points is approximately 60 km**
Glaciers are retreating in the mountains of Central Asia and this will affect water availability. Other important questions are about impacts of diminishing cryosphere on water quality including:

- **Dilution** and downstream water quality
- **Legacy pollutant release** from glaciers and bedrock weathering
- **Groundwater** quality
- **Water quality in reservoirs**

*The New York Times*

*Learning With: ‘Glaciers Are Retreating. Millions Rely on Their Water.’*

Hock et al. 2019 IPCC report Chapter 2. ‘High Mountain Areas’,

Sampling: 4 catchments/countries; bi-weekly: pH, T, EC, TDS, NO$_3^-$, PO$_4^{3-}$, Cations$^+$ and anions

High flow - HF

Low flow - LF

Dushanbe: 0.8 mill.

Tashkent: 2.4 mill.

Bishkek: 1.0 mill.

Discharge gauge

Groundwater samples

Reservoirs sample

Streamflow sample
Seasonal cycles of key meteorological variables and discharge

**Temperature**

**Precipitation**

**Potential ET**

**Discharge**

HF – high flow
Snow / Glacier melt
LF – low flow
Baseflow

*CRU TS 4.01 1991-2010*

Nutrients and total dissolved solids in upstream and downstream parts:

- The glacier melt dilution effect is clearly seen and its more pronounced downstream for NO₃ and TDS
- PO₄ is low in both periods (shown only upstream)

Close relationships between NO₃ and TDS and Flow?!
The glacier melt seems to bring NO$_3$ as nitrate concentration declines on downstream site towards the end of melt period.

- PO$_4$ has spikes in early autumn, first noted in GW upstream.

The stream water is very diluted upstream esp. during peak water.

- While downstream TDS drops in early autumn, evapoconcentration is less.

Nutrients and total dissolved solids in upstream and downstream:

- HF – Glaciers melt
- LF – baseflow
- KG – baseflow
- KG4 – baseflow

The graphs show changes in TDS, NO$_3$-N, PO$_4$-P, and other parameters over time from 22-May-19 to 22-Jan-20.
Uzbekistan. Pskem-Chirchik River - tributary of Syr-Darya River - UZ.

**HF** — Nutrients and total dissolved solids in upstream and downstream:

- NO$_3$ and TDS do not seem to depend much on flow.
- Nitrate concentrations are low both upstream and at the outlet — inflow to Syr Darya.

**LF** — baseflow

**Upstream** — Pskem River

**Downstream** — Chirchik River

Nutrients and total dissolved solids in upstream and downstream:

- NO$_3$ and TDS do not seem to depend much on flow.
- Nitrate concentrations are low both upstream and at the outlet — inflow to Syr Darya.

**Glaciers melt**

**HF** — Glaciers melts

**LF** — baseflow

**Glaciers**

**UZ1**

**UZ9**

**Tashkent**

**Chirchik**

**UZ9_Syr**

**Glaciers melt**

**HF** — Glaciers melts

**LF** — baseflow

**Glaciers**

**UZ1**

**UZ9**

**Tashkent**

**Chirchik**

**UZ9_Syr**
Nutrients and total dissolved solids in upstream and downstream:

- **NO$_3$** and TDS do not seem to depend on flow as in UZ with low concentrations in streamwater.
- **PO$_4$** is low in all samples.

**HF** – Glaciers

**LF** – baseflow

**GWP6**

**KG4**

**MH1**

**HF** – Glaciers

**LF** – baseflow
There is some evidence of elevated PTEs (such as As, Pb shown here) in HF period compared to LF also registered for Cu and Zn (not shown) ‘Legacy pollutants’?

This can be traced to glacier melt and contaminated snowpack (data for cryosphere samples for KZ and KG). January snowpack – Almaty city. June snowpack – Tuyuksu glacier, KZ. August snowpack – KG glaciers.

All PTEs are within regulatory standards set by WHO for drinking water (data across all sites)
Al in HF period can be clearly traced to glacier melt and contaminated snowpack (KZ and KG only).

It is unclear what is the source of Al – mineral dust or pollutants from Almaty and Bishkek which are large cities located in close proximity to glaciers. January snowpack – Almaty city. June snowpack – Tuyuksu glacier, KZ. August snowpack – KG glaciers.

Higher Cr concentrations are found in GW compared to streamwater.
Nutrients and Electrical Conductivity in different types of groundwater. Elevated Nitrate concentrations in urban groundwater.

- Systematically **high nitrate** (higher than 10 ml L\(^{-1}\) of NO\(_3\)-N set by WHO was found **urban groundwater** samples in three countries – KG, UZ, TJ.
- Phosphate concentrations are very low
- The low nitrate concentrations in springs and artesian groundwater indicate that fecal contamination is a likely primary source of elevated nitrate concentrations in urban shallow ground water
Conclusions

• Overall water in is clean upstream and downstream

• There is indeed contaminant leaching from snow and glacier melt (e.g. Al)

• Glacier melt provides dilution service to the downstream sections of the catchments. This effect is more pronounced in smaller catchments where urban and agricultural areas are located closer to the glacierized areas (e.g. KZ – Almaty and KZ – Bishkek)

• Urban groundwater is contaminated by nitrates most probably by urban sewage – primary concern