SEASONAL PATTERNS IN SEDIMENT FROM A GLACIER

Arctic rivers provide a major link between land and sea by transport of freshwater, sediments and nutrients. Long-term monitoring of river parameters is part of the GEM programme and essential to quantify total fluxes from the terrestrial to the marine ecosystem. The runoff and the water quality are closely linked to climatic conditions and processes in the surrounding landscape.

Photo 1: Muddy brown and clear water corresponding to high and low turbidity in Røde Elv. Photo: Charlotte Sigsgaard.

The river Røde Elv (Kuussuaq) near Qeqertarsuaq on Disko Island drains an area of approximately 96 km² (Fig. 1). The drainage basin is characterized by a unique volcanic genesis with layered basalts, and a typical mountainous periglacial landscape. A detailed morphologic mapping of the drainage basin was carried out in 2023 (Richter et al., 2025). The basin consists of glaciated areas and block fields at elevations above 700 m, steep unvegetated upper talus slopes with active mass movements between 300 and 700 m, and vegetated lower talus slopes with riverbanks below 300 m elevation. The central part of the drainage basin has a braided river system with relatively flat slopes. The river narrows to a single channel before it enters the Disko Bay.

As part of the GEM monitoring at Arctic Station, we monitor hydrological parameters at a gauging station near the Røde Elv river outlet, by deploying a multi-parameter sensor in the river soon after river breakup. In addition to the unattended data sampling, manual water sampling and discharge measurements are carried out to validate the data and convert water level and turbidity to water discharge and suspended sediment concentrations.

Winter runoff is observed in the area but hard to quantify as water runs beneath ice- and snow cover, or as surface meltwater on the snow. Most discharge in the river Røde Elv occurs between June and October. Seasonal patterns in hydrological parameters from the 2024 season are shown in Figure 2. The discharge illustrates a typical Arctic runoff pattern with high snowmelt driven discharge rates in the early part of the season, and a gradual decline with depletion of snow in the landscape (Fig. 2). This pattern is overlaid by event-peaks induced by either rain or extraordinary warm periods that increase melt water input from glaciers. The peak discharge of the 2024 season happened at the end of July as a response to several days of rain.

The mid-summer rain event also triggered the highest turbidity of the season (Fig. 2). Turbidity is a measure of water clarity and often adopted as a proxy for the suspended sediment concentration in the water (Photo 1). The turbidity

Figure 1. Outline of the river Røde Elv (Kuussuaq) drainage basin. The hydrometric gauging station is located near the outlet to the sea (yellow point) and the weather station AWS3 is located in Blæsedalen 90 m asl (blue point). The catchment varies in elevation from 0 to 900 m asl.

in 2024 closely follows the fluctuations in discharge. During the rain event, particles from surrounding land was washed into the river giving it a muddy reddish-brown color, which can be tracked as a visible plume reaching out in the marine near coastal zone (Photo 2). During high discharges, the water velocities are high and so is the potential for erosion along the riverbed and banks. The peak-event clearly illustrates a characteristic hysteresis loop with higher turbidity values during rising discharge and lower values during the falling discharge as sediment availability depletes (Fig. 3). The effect of rain events on the total export of sediment and nutrients is highly linked to intensity and seasonal timing. Late summer rain events, when the active layer is deepest, has potential for higher sediment loads, as thawed soils are more erodible, and a larger part of the drainage basin can deliver sediments and nutrients to the streams.

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Data source:

GEM GeoBasisDisko/ Hydrology/ Discharge

GEM GeoBasisDisko/ Hydrology/ Multisonde

GEM GeoBasisDisko/Meteorology/ AWS3-Meteorology

Data can be accessed on GEM database, https://data.g-e-m.dk

RIVER WATER AND SUSPENDED
FED CATCHMENT DURING SUMMER 2024

GEM
Greenland Ecosystem Monitoring

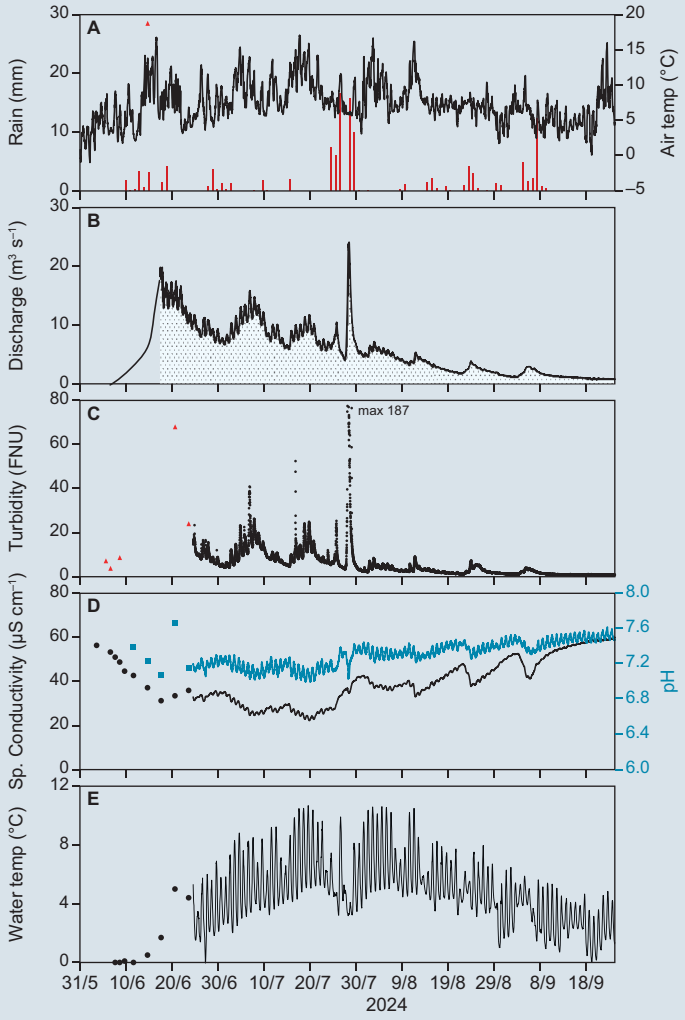

Figure 2. Seasonal variation in parameters measured at the hydrometric station during the main part of the runoff season in 2024 (Panel B to E). The upper panel (A) shows air temperature and daily sum of rain measured at the automatic weather station AWS3. The discharge (B) is estimated in the period from river breakup 7 June until 18 June due to snow and ice in the riverbed. In situ spot measurements of turbidity (C), pH (D), conductivity (D) and water temperature (E) cover the period until continuous measurements are available.

River water parameters like pH, conductivity and water temperature are indicators for the chemical composition of the water (Fig. 2, D and E). *In situ* measurements of pH indicate that the water in Røde Elv was slightly alkaline (7.0 to 7.6). Conductivity provides information about the concentration of dissolved ions/nutrient status in the water. The seasonal variation indicates shift in the relative dominance from various sources of water. Melt water from the glacier has a relatively low conductivity compared to soil water and therefore the conductivity shows a steady increase towards the end of the season, as input from the glaciers decreases.

Altered precipitation patterns, rising temperatures and permafrost degradation all have implications for the river systems and thereby the total transport of freshwater, nutrients and sediments from land to sea. Knowledge of the annual and inter annual variations in the river parameters is an important baseline for these quantifications. Daily mean runoff data from Røde Elv, along with those from Zackenberg and Kobbefjord (Nuuk) are reported to the Global Runoff Data Centre (GRDC) as the three sites representing Greenland.

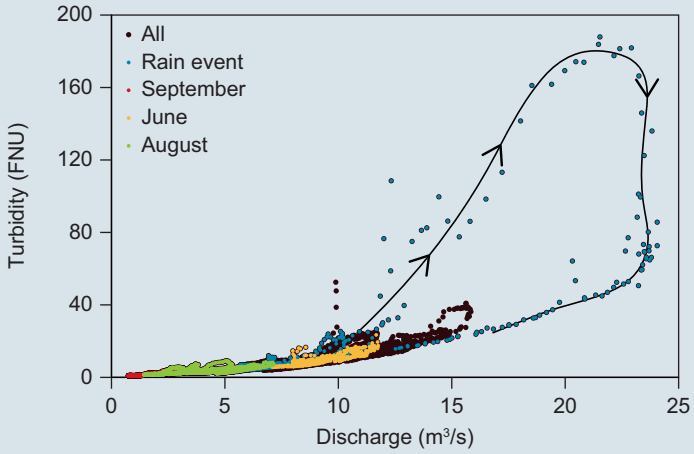

Figure 3. Turbidity versus discharge rates 2024. The line and arrow show the progress during the rain event. Turbidity increases during rising discharge and drops before the discharge drops as available sediments depletes.

Photo 2: The outlet of the river Røde Elv with a small plume of suspended sediment. The river gauging station is marked by the yellow dot. Photo: Gregor Luetzenburg.

References

Richter, U., Sigsgaard, C., Kroon, A. (2025): Geomorphological map for the watershed of the Røde Elv, Disko Island, CW Greenland (QGis Map Package) [dataset]. PANGAEA. (https://doi.pangaea.de/10.1594/PANGAEA.974723)