Hazardous Substance Load Estimation in a Small Catchment Using Baseflow Separation and Composite Sampling

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Introduction

Although to a different extent, but small streams can deliver significant load to their receivers. As the variability of streamflow decreases with the size of the river, in case of smaller rivers, markedly different pollutant concentrations might be associated with high flow events compared to low flow periods.The exact contribution of high flow events to the toal yearly load is unknown. The primary objective of my work is to refine the load estimation method using baseflow separation methods, specifically the Lyne-Hollick, Eckhardt and Rimmer-Hartmann methods. The methods were applied at two measuring stations of the Koppány stream in Somogy County, Hungary :Törökkoppány and Tamási.

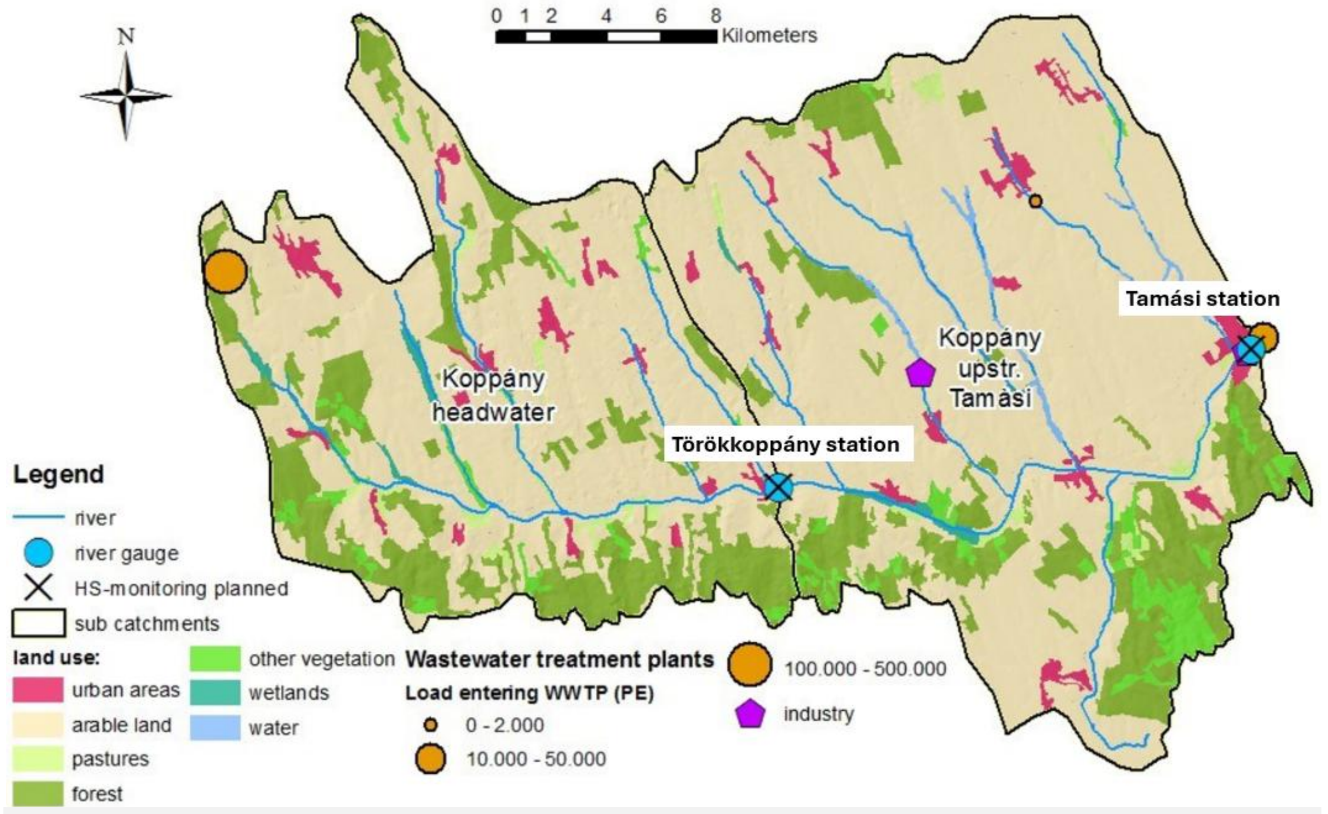

Fig. 1. The study catchment area of the Koppány Stream

1. Description of the catchment area

To ensure comprehensive monitoring, several key parameters are measured and analyzed:

- Hourly water flow measurements
- Electrical conductivity and turbidity are continuously monitored every five minutes
- Stratified sampling with an automatic sampler activated at a defined water flow threshold

This enables separate treatment of samples from baseflow and high flow, allowing better estimations of contaminant concentrations during high flow conditions and providing a more accurate load estimation.

Total flow (m³ s-1)	Tamási station	Törökkoppány station
10-year mean value	0.51	1.36
Study period mean value	0.35	1.05

Tab 1. Total flow mean values of the studied stations

2. The applied calculation methods for baseflow separation

The methods presented are designed to separate the streamflow into two components, a slowly varying baseflow from groundwater and highflow from rapidly varying runoff components (precipitation, surface runoff).

- Lyne-Hollick:

$$b_t = a \cdot b_{t-1} + \frac{(1-a)}{2} \cdot (Q_t + Q_{t-1})$$

- Eckhardt:

$$b_t = \frac{[(1-\beta)\alpha b_{t-1} + (1-\alpha)\beta Q_t]}{(1-\alpha\beta)}$$

The parameteres determined by the characteristics of the catchment under study. The R-H. method yielded realistic results only after including the wastewater entering the area as a third variable (in addition to the baseflow and quick flow) in the mixing equation. For this method, electrical conductivity (EC) was selected as the tracer, which is continuously registered at the measuring stations.

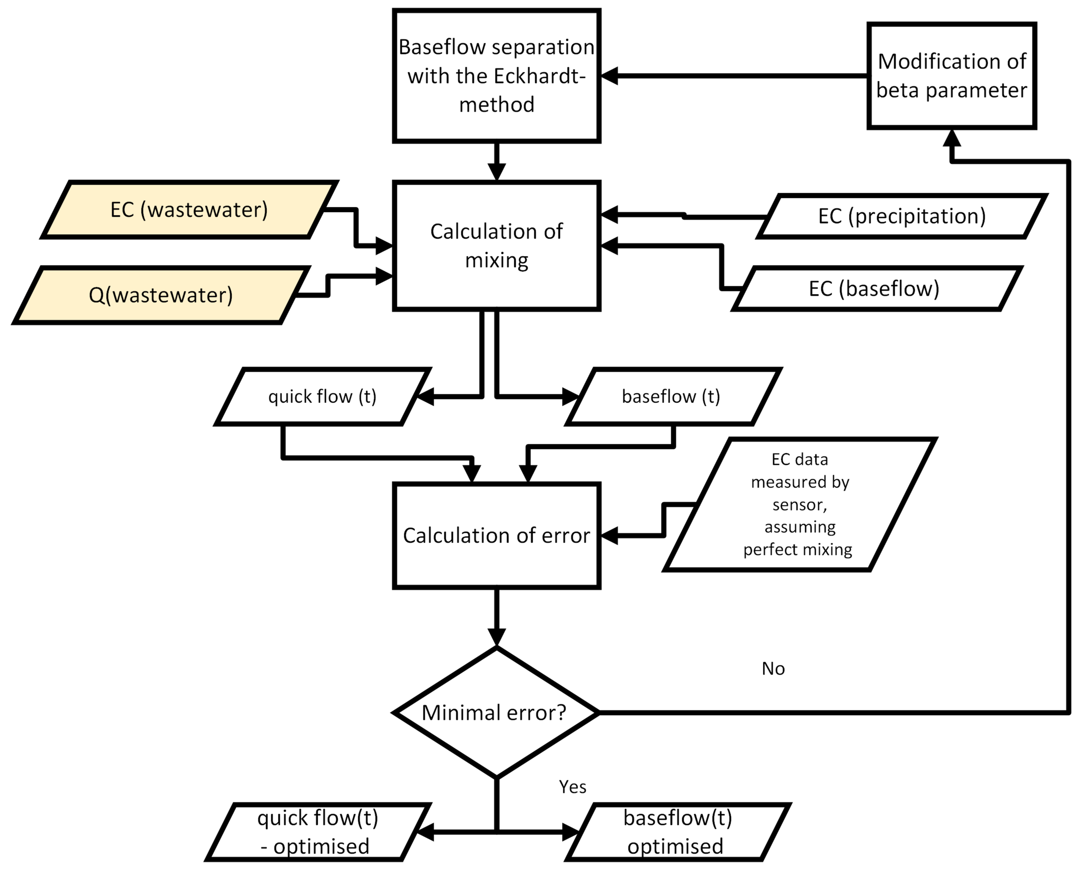

Fig. 2. Flowchart of baseflow separation with the modified R-H. method

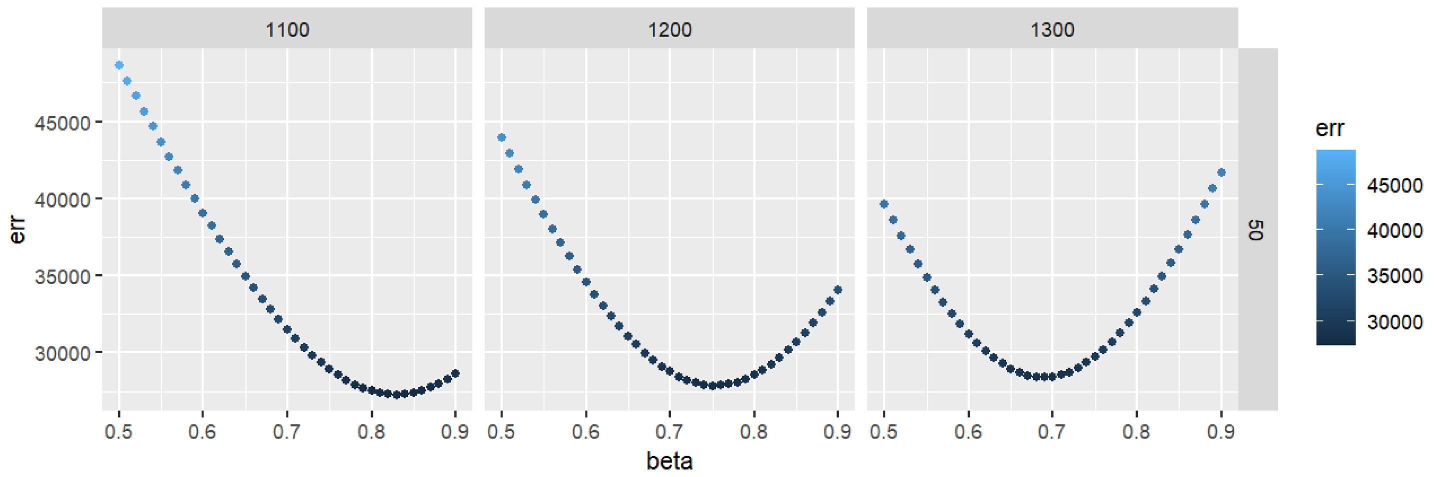

Fig. 3. Demonstration of parameter optimization with Tamási station data

In the mixing equation, in addition to the constant 1500 µS/cm wastewater and 50 µS/cm precipitation EC values, several baseflow EC values were used to find the ratio that results in the smallest error.

3. Results of the baseflow separation

Baseflow fraction (%) according to	Törökkoppány	Tamási
Lyne-Hollick	61%	86%
Eckhardt	57 %	57 %
Rimmer – Hartmann	100%	100 %
Modified Rimmer – Hartmann	57%	82%

Tab 2. Results of the L-H, Eckhardt, R-H, and modified R-H methods.

For Törökkopány site, all three methods resulted in similar results. The parameter optimization conducted as part of the R-H. method returned the initial value suggested by Eckhardt, which is 0.80 in this case (for perennial streams with a porous aquifer).

At the Tamás site, the Eckhardt method estimates a significantly higher high flow rate, which increases the estimated annual load values for the site by a considerable amount. The R-H. optimization resulted in an optimal value of the beta parameter of 0.83, which, while not significantly different from the 0.80 recommended by Eckhardt, altered the ratio of the baseflow and quick flow to such an extent that results similar to those estimated by the L-H. method were obtained.

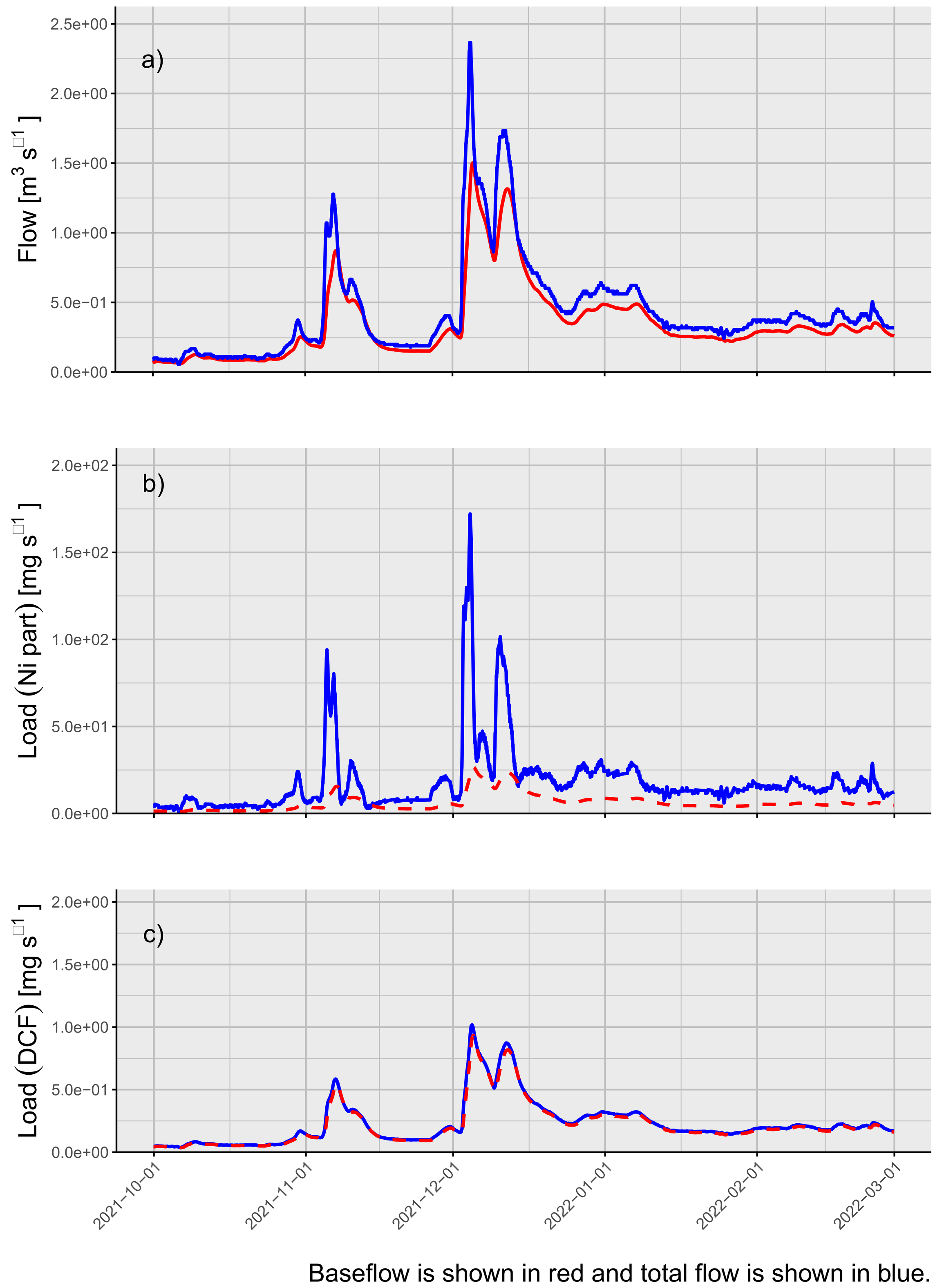

Fig. 4. The baseflow and total discharge of the Törökkoppány station (a), the baseflow load and total load for a typical high flow pollutant (particulate Nickel, b) and a typical baseflow pollutant (Diclofenac, c).

4. Estimated annual load values:

The annual load values (assigned separately to baseflow and high flow) are calculated by using the annualized water volume determined by these methods and the event concentrations for the baseflow and high flow data extracted by stratified sampling.

$$L = (q_t \cdot c_{mean,q}) + (b_t \cdot c_{mean,b})$$

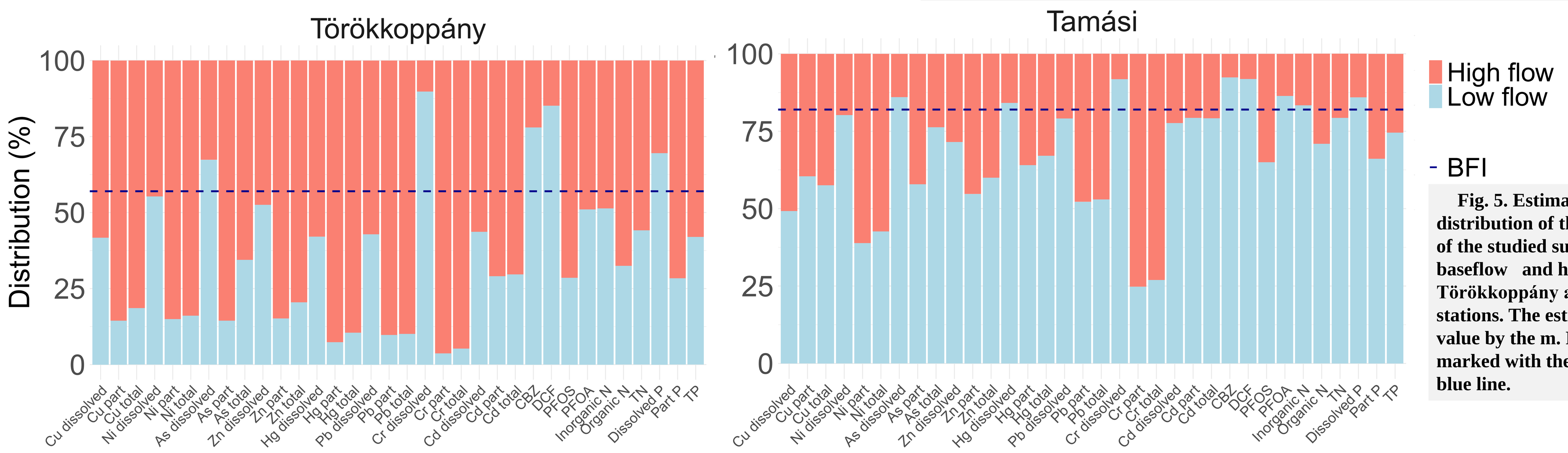

Fig. 5. Estimated distribution of the annual load of the studied substances in baseflow and high flow at Törökkoppány and Tamási stations. The estimated BFI value by the m. R-H. method is marked with the dark dashed blue line.

5. Conclusions

- The study demonstrated that while baseflow-separation methods can be effectively refined by accounting for significant point sources, such as wastewater discharge, their application may be complicated by local anthropogenic influences, including fishpond operations.
- Findings highlighted that pharmaceutical residues and dissolved metals predominantly originate from baseflow, whereas particulate-bound metals are largely transported during high-flow events, emphasizing the dual role of treated wastewater and sediment transport in shaping contaminant dynamics.
- A longitudinal shift from flood-driven to baseflow-associated pollutant transport was observed along the stream, underscoring the need for integrated sampling and monitoring approaches to accurately capture micropollutant and nutrient load distributions.

References:

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