Estimation of hazardous substance loads in a small catchment based on composite sampling

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Introduction

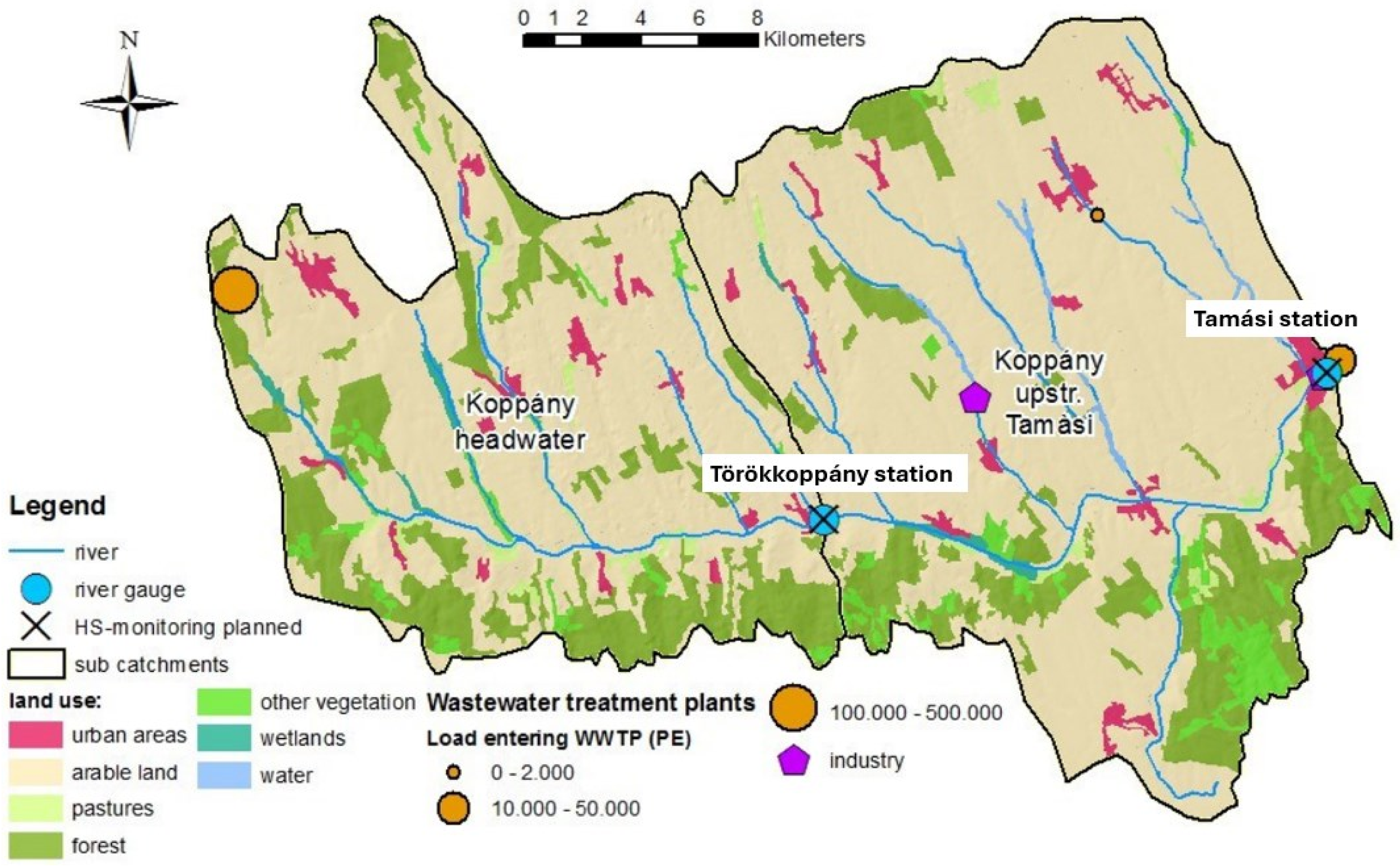
Although to a different extent, but small streams can deliver significant load to their receivers. As the variability of streamflow decreases with the size of the river, in case of smaller rivers, markedly different pollutant concentrations might be associated with high flow events compared to low flow 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 :Törökkoppány and Tamási.

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.



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:

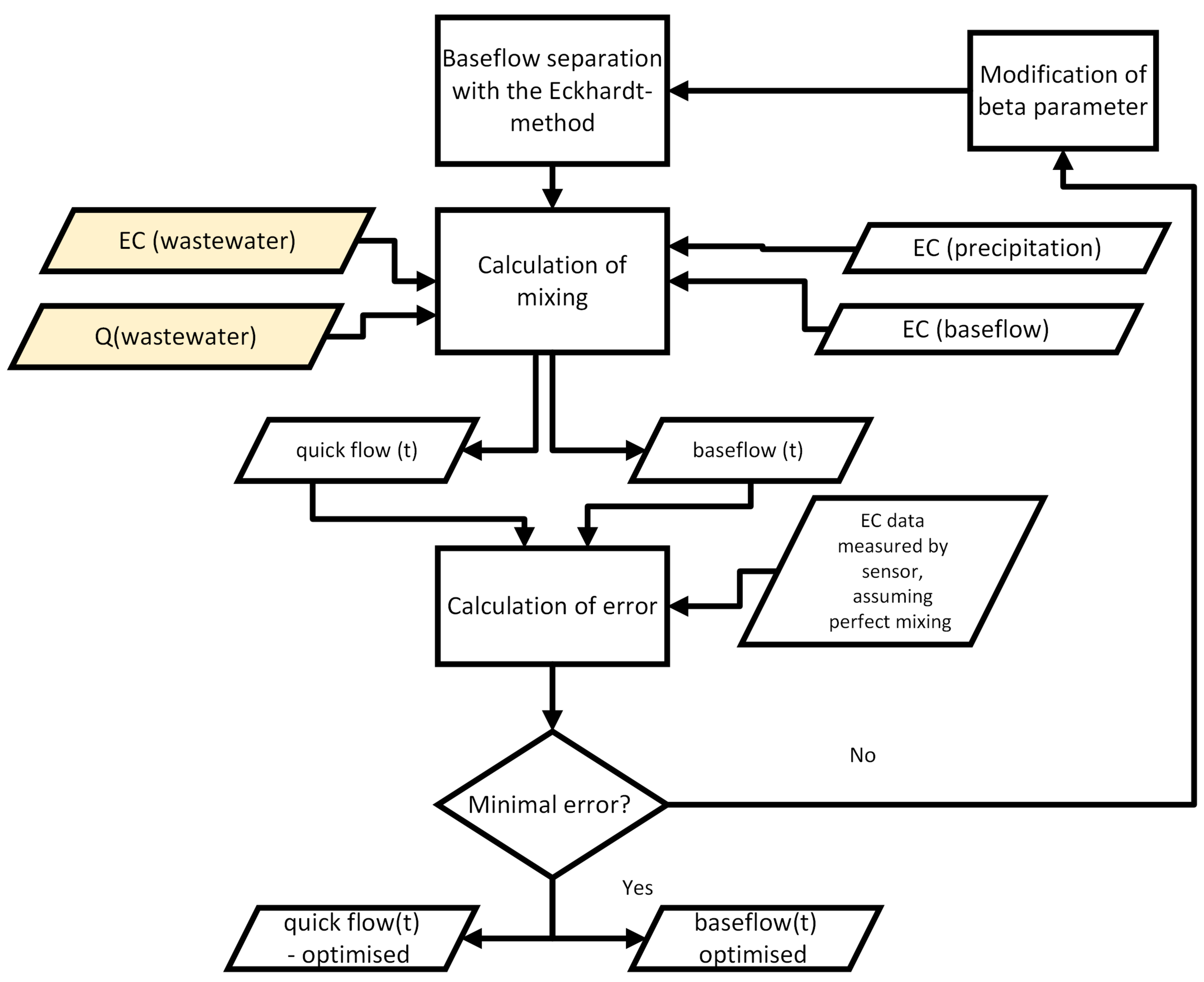
$$b_t = a \cdot b_{t-1} + \frac{(1-a)}{2} \cdot (Q_t + Q_{t-1})$$

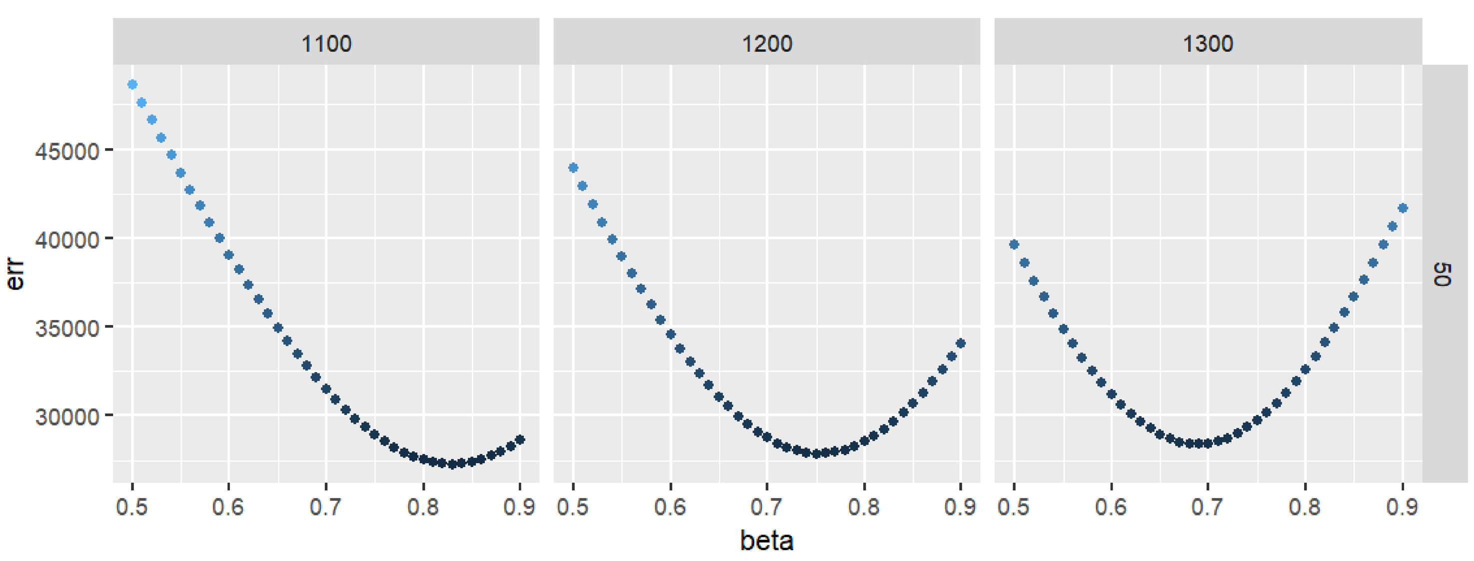
- Eckhardt:

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

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.





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

3. Results of the baseflow-separation		Baseflow	Highflow
Törökkoppány site	L-H.	6.64×10^6 m³	4.32×10^6 m³
		61%	39%
	Eckhardt	6.27×10^6 m³	4.70×10^6 m³
		57%	43%
	R-H.	6.27×10^6 m³	4.70×10^6 m³
		57%	43%
Tamási site	L-H.	2.85×10^7 m³	4.72×10^6 m³
		86%	14%
	Eckhardt	1.85×10^7 m³	1.48×10^7 m³
		56%	44%
	R-H.	2.74×10^7 m³	5.93×10^6 m³
		82%	18%

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).

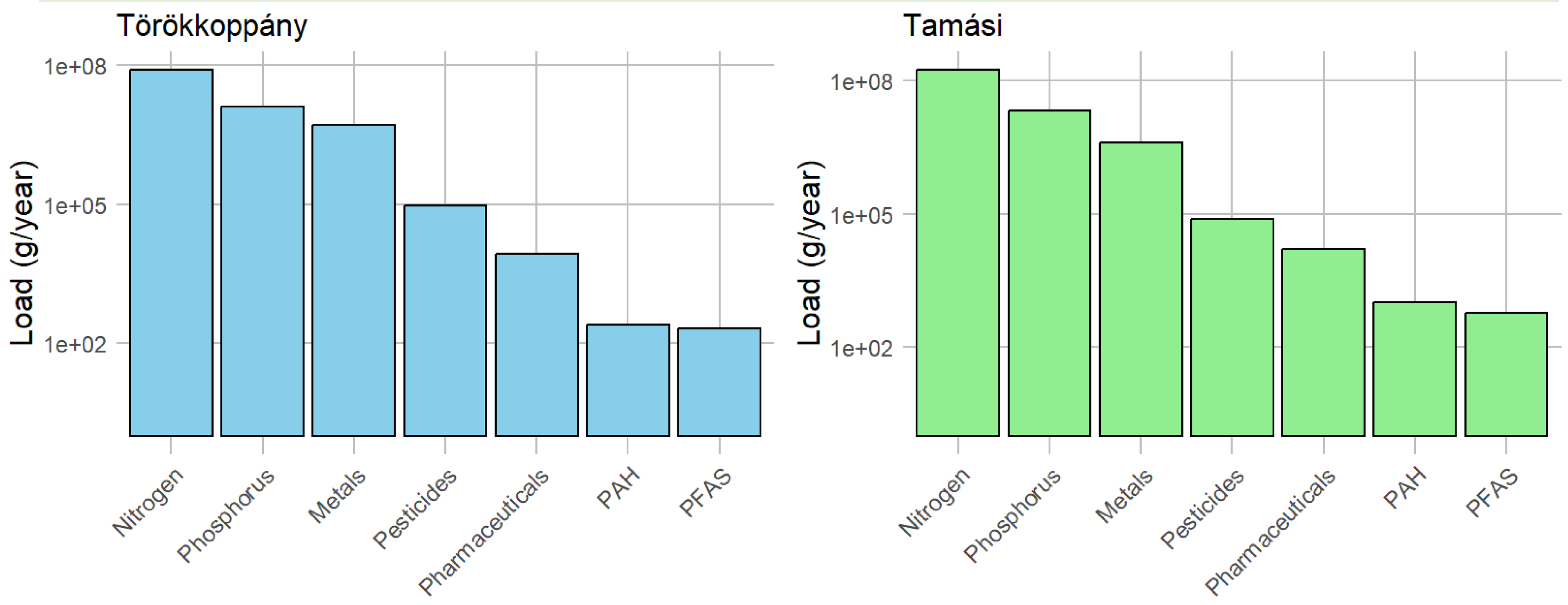
At the Tamás site, the Eckhardt method estimates a significantly higher high flow rate, which increases the estimated annual load values for the site by a considerable amount. The R-H. optimization resulted in an optimal value of the beta parameter of 0.83, which, while not significantly different from 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.

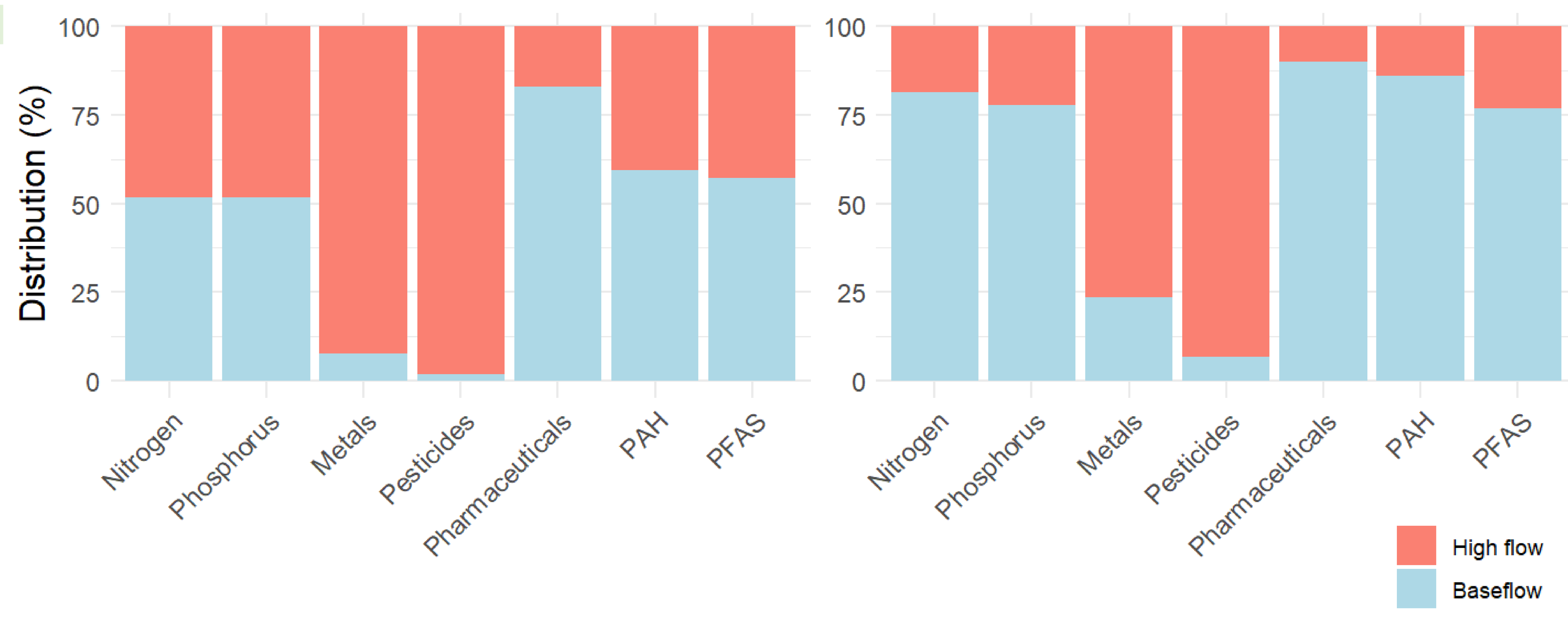
4. Estimated annual load values:

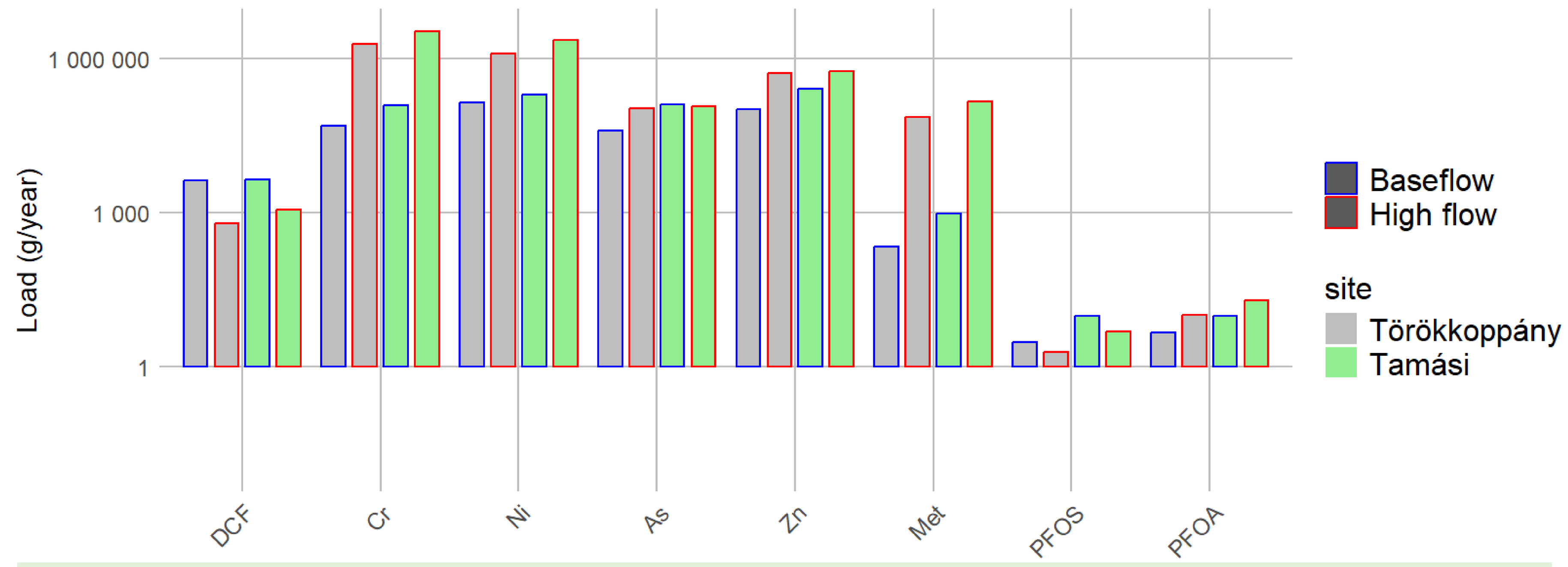
The annual load values (assigned separately to baseflow and high flow) are calculated by using the annualized water volume determined by these methods and the event concentrations for the baseflow and high flow data extracted by stratified sampling.

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

The plots below show the load values calculated using the results of the modified Rimmer-Hartmann method, determined for one year.







5. Conclusions

- At Tamási station, experience from the calculation results suggests that the Eckhardt method overestimates the ratio of high flow, presumably due to artificial high flow conditions generated by pond farms in the area, while the Lyne-Hollick method does not seem to be greatly affected of it.
- Pharmaceutical substances and PFAS are more likely to be found in the baseflow, presumably from treated wastewater being discharged into the stream.
- A significant proportion of the various forms of pesticides and metals are predominantly present in the highflow, which can be linked to agricultural activity in the catchment, making soil the main source of these pollutants in the area.
- By paying more attention to the removal of pharmaceuticals and metals (with the help of active carbon adsorption, ozonation, coagulation) and by more careful agricultural activities (less pesticide use), the load could be significantly reduced for pharmaceuticals, PFAS compounds, pesticides and heavy metals.

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