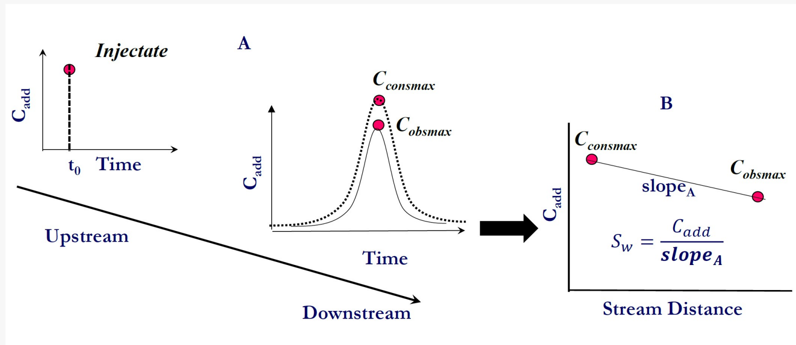
A Smarter Way to Measure How Streams Clean Themselves

GA, UNITED STATES, May 19, 2026 /EINPresswire.com/ -- A widely used method for measuring how well streams absorb excess nutrients has a hidden flaw: it systematically overestimates uptake length under high-nutrient conditions. Researchers at Duke Kunshan University have derived a corrected zero-order analytical approach that better captures stream nutrient processing when nutrients are abundant, improving the accuracy of tools used to assess river health and guide restoration decisions.



Conceptual diagram illustrating the zero-order approach for pulse nutrient addition experiments.

Rivers and streams act as natural nutrient filters: microbes and plants in the streambed absorb nitrogen, phosphorus, and other pollutants as water flows downstream. Scientists measure this filtration capacity using “uptake length” (Sw) — the average distance a nutrients travel before being absorbed. A shorter Sw signals a healthier, more efficient stream.

For decades, Sw has been calculated using a first-order kinetic model that assumes nutrient removal is always proportional to concentration — a log-linear relationship. Simple and widely adopted, this approach is embedded in the dominant field framework known as TASCC. But it has a hidden flaw: it breaks down under nutrient-saturated conditions, precisely those found in agricultural watersheds, urban catchments, and high-load experiments. When biological uptake is running near its ceiling, the actual nutrient decline with distance is linear, not exponential. Forcing a log-linear fit onto linear data systematically inflates Sw — by up to 48% in constant-addition experiments and up to 2.4-fold in pulse injections.

“Systematic overestimation can lead managers to conclude a degraded stream filters nutrients more effectively than it does, misdirecting investment and regulatory effort,” says Chuanhui Gu from Duke Kunshan University, lead and corresponding of a new study published in HydroResearch.

As agricultural intensification and urban growth push more streams into nutrient-saturated conditions, the problem is becoming more common, not less.”

Together with co-author Yinuo Yang, Gu offers a direct fix. Drawing on Michaelis–Menten enzyme kinetics, the authors derive a zero-order analytical approach that fits an arithmetic decline in nutrient concentration rather than a log-transformed one.

Validated against 200 Monte Carlo simulations using a reactive transport model as “ground truth,” the zero-order method substantially outperforms the first-order approach under saturation, while the first-order method remains appropriate when nutrients are limiting.

“For researchers using TASCC, we propose a hybrid correction: keep the standard log-linear derivation for the low-concentration tails of the breakthrough curve, but apply the zero-order approach at the high-concentration peak — the segment most critical for estimating maximum uptake rate. No new equipment or experimental redesign is required,” says Yang.

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saturation, while the first-order method remains appropriate when nutrients are limiting. A simple diagnostic guides the choice: if the system is nutrient-saturated and more than 40% of added nutrient is absorbed before the sampling point, the zero-

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References
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