A Coupled Flow and Solute Transport Model for Real-time Monitoring of Conservative River Pollutants using Remote Sensing Observations

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ABSTRACT

Real-time monitoring of at-site water quality parameters and their spatiotemporal transports in ungauged rivers, characterized by unsteady flows, is essential for riverine water quality management. However, the available unsteady solute transport models have limited use in coarse-scale ungauged river applications due to their numerical complexity, difficulty in unifying both the flow and solute transports owing to separate numerical schemes in solving these two mechanisms, and numerical stability problem in the solution schemes. Among the existing simplified and physically-based flow transport models, the Variable Parameter McCarthy–Muskingum (VPMM) model has the ability to be used in ungauged river system. Conversely, this model ignores the floodplain flows, catchment dynamics of spatiotemporally distributed lateral flow generation and its contribution along the river reach. Further, the conventional laboratory and digital in-situ methods are not always feasible for real-time monitoring of pollutants. Hence, a numerical-error free integrated flow and solute transport modeling framework was developed herein for real-time monitoring of heavy metal pollution in ungauged rivers using the satellite-based remote sensing (RS) data products, which could be applicable under both the steady and unsteady flow conditions.

To achieve this objective, this study i) revised the VPMM model for floodplain flows accounting for spatiotemporal variability of lateral flows; ii) developed three variants of physically-based coupled VPMM-AD (Advection-Dispersion) models suitable for meso-scale flow and solute transports, and tested their performances with the benchmark MIKE11-AD model; iii) developed the Spatial and Temporal Adaptive Reflectance Fusion Model (STARFM)-based spectral algorithms using satellite-based Landsat and Moderate Resolution Imaging Spectroradiometer (MODIS) imageries for at-site real-time heavy metal pollution mapping at 30-m×1-day resolutions during cloud-free days; and iv) advocated an integrated VPMM-AD(ΨD_c)-RS approach for real-time monitoring of non-reactive river pollutants during cloudy periods. The developed approaches were evaluated using the numerical experiments, published laboratory and river-reach scale flow and tracer datasets, and observed flow and pollutant datasets of the Brahmani River in eastern India. The results revealed that the developed VPMM-AD(ΨD_c)-RS approach has a greater and consistent field-applicability in modeling the transport dynamics of flow rate, flow depth and concentrations of the conservative solutes in ungauged rivers than the popular MIKE11-AD model.

***Keywords*:** Flow, Heavy metal, Remote sensing, Routing, Solute transport, Ungauged, VPMM-AD