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Effects of land use and water quality on greenhouse gas emissions from an urban river system

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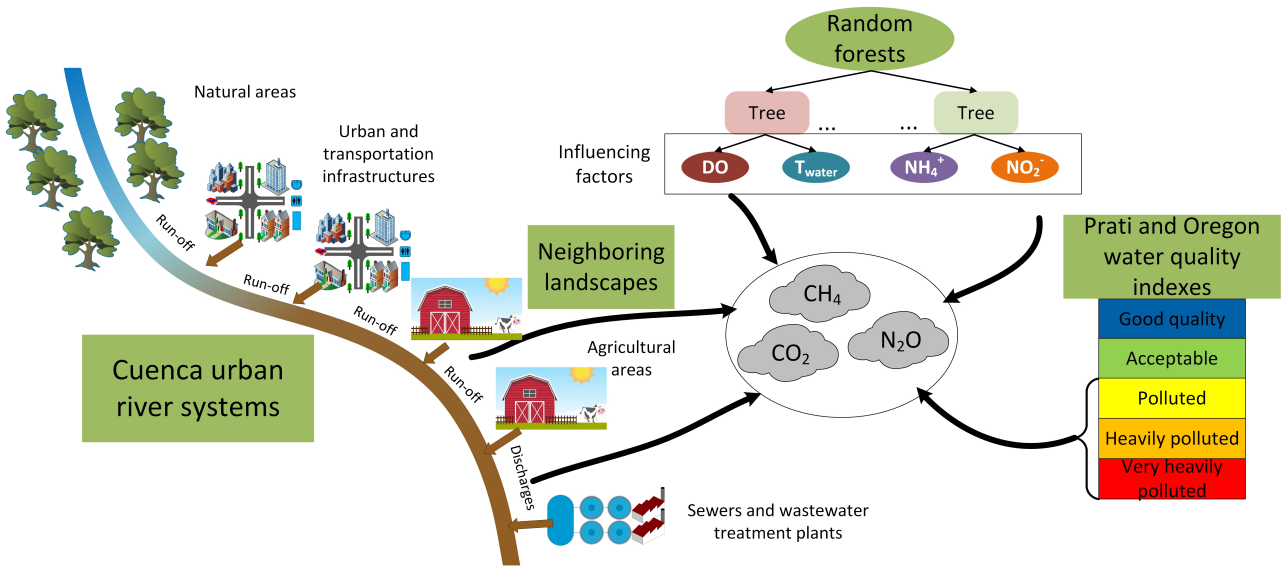
Abstract Text:

Rivers act as a natural source of greenhouse gases (GHGs) that can be released from the metabolisms of aquatic organisms. Anthropogenic activities can largely alter the chemical composition and microbial communities of rivers, consequently affecting their GHG emissions. To investigate these impacts, we assessed the emissions of CO_2, CH_4, and N_2O from Cuenca urban river system (Ecuador). High variation of the emissions was found among river tributaries that mainly depended on water quality and neighboring landscapes. By using Prati and Oregon Indexes, a clear pattern was observed between water quality and GHG emissions in which the more polluted the sites were, the higher were their emissions. When river water quality deteriorated from acceptable to very heavily polluted, their global warming potential (GWP) increased by ten times. Compared to the average estimated emissions from global streams, rivers with polluted water released almost double the estimated GWP while the proportion increased to ten times for very heavily polluted rivers. Conversely, the GWP of good-water-quality rivers was half of the estimated GWP. Furthermore, surrounding land-use types, i.e. urban, roads, and agriculture, significantly affected the river emissions. The GWP of the sites close to urban areas was four time higher than the GWP of the nature sites while this proportion for the sites close to roads or agricultural areas was triple and double, respectively. Lastly, by applying random forests, we identified dissolved oxygen, ammonium, and flow characteristics as the main important factors to the emissions. Conversely, low impact of organic matter and nitrate concentration suggested a higher role of nitrification than denitrification in producing N_2O. These results highlighted the impacts of land-use types on the river emissions via water contamination by sewage discharges and surface runoff. Hence, to estimate of the emissions from global streams, both their quantity and water quality should be included.



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Plain-Language Summary:
Rivers are being polluted by human activities, especially in populated urban areas. Our studies investigate the impacts of these activities on greenhouse gas (GHG) emissions from an urban river system. The results showed a clear trend between water quality and GHG emissions in which the more polluted the sites were, the higher were their emissions. Specifically, when river water quality deteriorated from acceptable to very heavily polluted, their contribution to global warming increased by ten times. Conversely, good-water-quality rivers contributed only half to global warming compared to the average estimated emissions from global rivers. Furthermore, surrounding land-use types, i.e. urban, roads, and agriculture, significantly affected the river emissions. Rivers closed to urban areas released more than four-time of the amount of the major GHGs compared to rivers closed to the nature sites. By applying machine learning, we were able to identify the main important factors to the emissions from urban river systems. These results highlighted the impacts of land-use types and water quality on the river emissions which can be used to estimate the emissions from the global rivers.

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Previously Published Material:
The preliminary results of the study was presented in IWA-IDB Innovation Conference 2019 with the title "Greenhouse Gas Emissions from the Integrated Urban Wastewater Systems in Cuenca".The final results of the study was written as a manuscript which is currently under review in Science of the Total Environment.

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