PhD in Civil and Environmental Engineering

Research Title: River Network Self-Depuration

Funded by	Politecnico di Torino (Joint Research Projects with Top Universities)

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Context of the research activity	Rivers play a paramount role for humans and the environment because they represent abundant and accessible sources of water for drinking, irrigation, and energy production, provide habitats for fish and plant species, and transport nutrients through the catchment thus making them available to the organisms living along the river corridor. Nitrogen-based fertilizers are a recognized example of nutrients that are massively applied in agricultural areas, leading to diffuse contamination, eutrophication, and oxygen depletion in receiving water bodies. Excess nitrogen in the environment has also a huge economic impact for the European Union, which has been estimated to range between 70 and 320 billion of Euros per year. Nutrients released in watersheds are not simply transported through aquifers and stream networks, but they are retained in a number of biogeochemical hotspots whose physical, chemical, and biological properties favor their transformation and degradation. The majority of these hotspots occur at interface regions such as streambeds and riparian sediments. Here, physicochemical conditions enhance the development of microorganisms that harness energy for their growth and sustainment from the transformation of many different chemicals. Delivery of these chemicals to sediments is controlled by water exchange flow between surface water and groundwater, and this exchange flow is in turn strongly influenced by landscape and stream morphology.

Objectives	The research objective is to develop a novel mathematical framework to quantitatively predict the watershed response to nutrient and contaminant loads. This innovative framework will be based on an integrated description of stream morphology, hydrodynamics, and biogeochemistry to determine the extent of nitrogen removal from the water cycle. Detailed surveys and publicly available data of landscape topography and stream morphology along the river network will be used together with extended versions of state-of-art water and nutrient transport approaches to predict patterns of exchange flow and contact

	times between chemicals and biogeochemically active sediments. In this way, this novel modeling framework will provide an overall estimation of the response of riverine ecosystems to different nutrient loads. The modeling framework will be specifically designed to be able to include different pieces of information - from typically available data to novel research findings - in a flexible way to enhance future implementations by water management agencies.

Skills and competencies for the development of the activity	The candidate should have skills in mathematical modeling (e.g. Matlab). Competencies in solute transport in rivers and groundwater will be appreciated. The activity will be developed in collaboration with prof. Stanley Grant at UCI - the University of California at Irvine (USA). During the PhD, the candidate will have to spend a total of 18 months at UCI.