Flow and solute transport in emergent aquatic plant canopies

ABSTRACT

With wetlands constituting about 6% of earth's land surface, aquatic vegetation plays a significant role in the transport of dissolved and particulate material in the environment, such as nutrients, pollutants, and sediment. In this talk, we consider the lateral dispersion of passive solute in arrays of randomly-distributed cylinders, a model for emergent aquatic plants. Previous models predict that lateral dispersion increases monotonically with cylinder density at all Reynolds numbers. I will present laboratory measurements which show that, in contrast, lateral dispersion at high Reynolds number exhibits three distinct regimes. In particular, the measurements reveal an intermediate regime in which dispersion decreases with increasing cylinder density. I will present a scale model for turbulent diffusion which, when superposed with existing models for dispersion due to the spatially-heterogeneous velocity field that arises from the presence of the cylinders, accurately captures the observed dependence of dispersion on cylinder density. The cylinder density-dependence of lateral dispersion may have important implications for organisms that use chemical signals to locate their prey or mate, and for the design of artificial wetlands, which are used to treat domestic, agricultural, and industrial wastewater.