Thermodynamics of Saline and Fresh Water Mixing in Estuaries

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Mixing of saline and fresh water is a process of energy dissipation. The fresh water flow that enters an estuary from the river contains potential energy with respect to the saline ocean water. This potential energy is able to perform work. Looking from the ocean to the river, there is a gradual transition from saline to fresh water and an associated rise of the water level in accordance with the increase of potential energy. Alluvial estuaries are systems that are free to adjust dissipation processes to the energy sources that drive them, primarily the kinetic energy of the tide and the potential energy of the river flow, and to a minor extent the energy in wind and waves. Mixing is the process that dissipates the potential energy of the fresh water. The Maximum Power (MP) concept assumes that this dissipation takes place at maximum power, whereby the different mixing mechanisms of the estuary jointly perform the work. In this paper, the power is maximized with respect to the dispersion coefficient that reflects the combined mixing processes. The resulting equation is an additional differential equation that can be solved in combination with the advection-dispersion equation, requiring only two boundary conditions for the salinity and the dispersion. The new equation has been confronted with 52 salinity distributions observed in 23 estuaries in different parts of the world and performed very well, even better than the well-tested empirical Van der Burgh equation that required a calibration parameter, which with this equation is no longer needed.