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The influence of hydrodynamical regimes on mixing at river confluences

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Mixing processes at the confluence of large rivers can have significant practical implications for water quality management and ecosystem processes. Theory suggests that the distance required for complete downstream mixing due to turbulent diffusive processes increases as the square of post junction width, which partly explains why big rivers can take so long to mix. However, field observations suggest that the same river may mix much more rapidly under certain hydrodynamic conditions. This suggests that advection may also be important and that long mixing distances are associated with a significant weakening of the intensity of transverse mixing due to advection. This has been observed and discussed in the literature.. To explain this phenomenon, several hypotheses have been proposed. One of the possible mechanisms for explaining the "suppression" of transversal mixing is the formation of a near vertical shear layer and counter-rotating vortices that serve to keep the two tributary channels separate. Rapid decay of the intensity of shear between the two joining flows rapidly reduces the intensity of turbulence driven mixing. We test this hypothesis in a computational experiment using a three-dimensional formulation, for the junction of the Kama River and the Vishera River. Numerical results have shown that at sufficiently large flow rates, downstream the rivers confluence, their waters practically do not mix in the horizontal direction throughout the depth over long distances from the confluence. The reason for the weakening of transverse mixing is the formation of a two-vortex flows downstream of the junction under two related conditions: (1) relatively similar discharge ratios; and (2) high discharge conditions. With relatively similar discharge ratios, it is not possible for one vortex to come to dominate the channel and increase the rate of advection due to mixing. At higher discharges, such vortices persist for a greater distance downstream. Thus, whether or not, for a given junction, secondary circulation leads to significant advective mixing depends on the relative discharge of the two upstream tributaries.

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