EGU21-13214
https://doi.org/10.5194/egusphere-egu21-13214
EGU General Assembly 2021

From inflow to interflow, through plunging and lofting: uncovering the dominant flow processes of a sediment-rich negatively buoyant river inflow into a stratified lake

Stan Thorez[1], Koen Blanckaert[1], Ulrich Lemmin[2], and David Andrew Barry[2]
[1]Institute of Hydraulic Engineering and Water Resources Management, TU Wien, Vienna, Austria (stan.thorez@tuwien.ac.at)
[2]Ecological Engineering Laboratory, Lausanne Federal Institute of Technology, Lausanne, Switzerland

Lake and reservoir water quality is impacted greatly by the input of momentum, heat, oxygen, sediment, nutrients and contaminants delivered to them by riverine inflows. When such an inflow is negatively buoyant, it will plunge upon contact with the receiving ambient water and form a gravity-driven current near the bed (density current). If such a current is sediment-laden, its bulk density can be higher than that of the surrounding ambient water, even if its carrying fluid has a density lower than that of the surrounding ambient water. After sufficient sediment particles have settled however, the buoyancy of the current can reverse and lead to the plume rising up from the bed, a process referred to as lofting. In a stratified environment, the river plume may then find its way into a layer of neutral buoyancy to form an intermediate current (interflow). A deeper understanding of the wide range of hydrodynamic processes related to the transitions from open-channel inflow to underflow (plunging) and from underflow to interflow (lofting) is crucial in predicting the fate of all components introduced into the lake or reservoir by the inflow.

Field measurements of the plunging inflow of the negatively buoyant Rhône River into Lake Geneva (Switzerland/France) are presented. A combination of a vessel-mounted ADCP and remote sensing cameras was used to capture the three-dimensional flow field of the plunging and lofting transition zones over a wide range of spatial and temporal scales.

In the plunge zone, the ADCP measurements show that the inflowing river water undergoes a lateral (perpendicular to its downstream direction) slumping movement, caused by its density surplus compared to the ambient lake water and the resulting baroclinic vorticity production. This effect is also visible in the remote sensing images in the form of a distinct plume of sediment-rich water with a triangular shape leading away from the river mouth in the downstream direction towards a sharp tip. A wide range of vortical structures, which most likely impact the amount of mixing taking place, is also visible at the surface in the plunging zone.

In the lofting zone, the ADCP measurements show that the underflow undergoes a lofting movement at its edges. This is most likely caused by a higher sedimentation rate due to the lower velocities at the underflow edges and leads to a part of the underflow peeling off and forming an interflow, while the higher velocity core of the underflow continues following the bed. Here, the

baroclinic vorticity production works in the opposite direction as that in the plunge zone. Further downstream, as more particles have settled and the surrounding ambient water has become denser, the remaining underflow also undergoes a lofting motion. The remnants of these lofting processes show in the remote sensing images as intermittent ‘boils’ of sediment rich water reaching the surface and traces of surface layer leakage.