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Transportational cyclic step formation in subaqueous environment

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Supercritical flow in the Richardson sense over a steep fragile bed may generate ephemeral short wave bed forms like antidunes, most commonly observed to migrate upstream. In some cases, however, antidunes give way to a much more stable cousin bounded by internal hydraulic jumps in the flow above them, which stabilize the flow morphodynamics while leaving depositional records unlike the antidunes. This long wave manifestation of the instability is christened as cyclic steps, by researchers and categorized under two main folds;erosional steps and transportational steps.

In subaqueous environments positive feed back between turbidity currents and the erodible bed gives rise to sediment waves and circumstantial evidences by numerical simulations and field observations have proven these sediment waves are non other than the cyclic steps. Studies related with the subaqueous cyclic step formation are not abundant and idealized models employing the mathematical elucidation of this formation phenomenon yet to be tested in this research arena. This is an endeavor to mathematically elaborate the formation of transportational cyclic step in subaqueous environment powered by the density driven turbidity current.

An idealized model has been developed preserving the essential physics of the system, employing one dimensional (1D) shallow water equations along with the dispersion equation of suspended sediment and Exner equation of sediment continuity. Assuming the interaction of sea water with the turbid underflow is considerably small in most of the region of our concern entrainment coefficient related terms are dropped in the continuity equation of the turbidity current. Being on the logic that the response of flow is sufficiently quick compared with the response of bed, quasi steady assumptions are employed during the solution phase for further simplification of the governing equations. Conservation of the suspended sediment through the hydraulic jump, zero bed evolution at the either ends of the selected step, specified threshold velocity for the incision of the bed erosion at the upstream end of the step and the Richardson critical conditions at the origin of the stream wise coordinate are employed as boundary conditions during the rigorous calculation procedure.

Considering a single step which migrates upstream preserving its shape, model is solved starting from the vicinity of the Richardson critical point where flow transits from sub critical to supercritical, to obtain the shape of the step along with the behavior of the characteristic parameters govern this formation process at the so called base state.

Keywords: cyclic steps, turbidity currents, subaqueous environment, 1D shallow water equations