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EXTENDED ABSTRACT

Experimental Study of Sedimentary Interflow Density Current Body Height in Separation Point From Bed

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Introduction

Underflow density currents traveling through density-stratified fluids begin to separate from the bed as they reach areas of similar densities, after which they continue their path as interflows through the surrounding ambient fluid. This point, which is referred to as "separation point" of density currents, acts as the boundary between the underflow and interflow density currents. A density current within a stratified environment is known as intrusive gravity currents (IGC), which travel horizontally at a roughly constant velocity U within the stratified layer after propagation (Nokes et al., 2008). Regarding underflow density currents, efforts have been made by many researchers *e.g.* Singh, and Shah (1971), Lee, and Yu (1997) and Farrell, and Stefan (1986) in the past decades to determine the location of the plunge point of underflow density currents (which is similar to the separation point in interflow currents) using experimental and theoretical methods based on the Densimetric Froude Number at the plunge point $F_{p.}$ Although studies have been conducted on interflow density currents, including Kao (1977), Wells, and Nadarajah (2008), An, and Julien (2014) and Zhang et al. (2015). Not any research has been found in the literatures about the height of density current at the point of separation from the bed. Hence, in addition to examining the height variations in density currents at the separation point with respect to changes in hydraulic parameters such as flow rate, density of the flow at the inlet, as well as the bed slope, the present study attempted to derive a relation for prediction of density current height at the point of separation from the bed under different conditions.

Methodology

A total of 48 experiments were conducted at different densities and flow rates in a gradient flume to investigate the height variations at the separation point in density currents. An opening gate was implemented at the beginning of the flume and the space behind which was used as the tank for input turbidity current. To prepare a fluid with saline stratification in the flume, dense ambient saline water was prepared by dissolution salt in water in a container. After reaching to the desired salinity, the saline water was pumped into the flume through the opening up to a covering of 1-m distance. Then, the tap water was released over the saline water with a low velocity to allow formation of the desired fluid with saline stratification using the diffusion phenomenon. After formation of the fluid with saline stratification, the salinity level at different flume cross-sections was measured by using the digital EC meter. On the other hand, the density sedimentary current (which is a mixture of silica and water) was prepared in a separate tank and conveyed into the container behind the entrance gate at a certain flow rate through an inlet valve. When the turbidity fluid in the container reached to the same height as that of the ambient fluid in the flume, the sliding gate was immediately opened to allow the turbidity current enter the flume with saline stratification fluid. In this case, the sedimentary density current initially moved as an underflow current due to its heavier weight compared to the surrounding fluid layers. When the current reached to a layer with same density, the turbidity current was separated from the flume bed and penetrated the surrounding fluid as an interflow density current. A summary of the experiments conducted in this project is provided in Table 1.

Table 1- A summary of the experiments conducted in this research

Number	*Slope (%)*	*Discharge (l/s)*				*Concentration (g/l)*			
16	2.5	1	1.5	2	2.5	5	10	15	20
16	3.25	1	1.5	2	2.5	5	10	15	20
16	4	1	1.5	2	2.5	5	10	15	20

Results and Discussion

In this study the average height of the density current at the point of separation from the bed was investigated with respect to the flow rate and density of the current at the inlet as well as the slope of the flume. It was found that the average flow height at the separation point was increased by increasing the flow rate. In summary, by increasing the flow rate from 1 l/s to 2.5 l/s, the average height of the density current at the separation point for all slopes was increased by 26, 30, 40, and 46% at concentrations of 5, 10, 15, and 20 g/l, respectively. Based on the density results, by increasing the density of the turbidity current, the average height of the flow at the separation point was decreased, such that by increasing the density from 5 g/l to 20 g/l, the average height of the flow in all flume slopes was decreased by 31, 20, 27, and 21 percent at flow rates of 1, 1.5, 2, and 2.5 l/s, respectively. The results showed that when the bed slopes were changed to the higher bed slope, the aforementioned heights were increased. However, this increasing effect was attenuated as the concentration of the density current was increased. At all cases, by increasing the slope from 2.5% to 4%, the average height of the flow at the separation point for all the flow rates and densities was increased by 29%.

The Densimetric Froude Number at the plunge point was calculated for three different slopes (2.5, 3.25, and 4 percent). Based on the results, for all these slopes, the flow at the point of separation from the bed assumes a subcritical state due to the Densimetric Froude Number lower than 1. Moreover, the Densimetric Froude Number ranges at the separation point was calculated from 0.17 to 0.46.

Ultimately, dimensional analysis was applied on the effective parameters to extract a dimensional and a dimensionless relation to predict the height of density current at the separation point. The dimensional and dimensionless relationships were obtained using nonlinear regression method by statistical analysis (SPSS) based on 60% and 80% of the experimental results with correlations of 0.92 and 0.75, respectively obtained. The remaining data were used for verification purposes. It was concluded that the proposed relations were able to estimate these perimeters with acceptable accuracy.

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