Dilution in Transition Zone between Rising Plumes and Surface Plumes

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DILUTION IN TRANSITION ZONE BETWEEN RISING PLUMES AND SURFACE PLUMES

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ABSTRACT

When sewage is discharged from sea outfall diffusers in shallow water the plume rises towards the water surface in the so-called initial dilution zone because of density difference between the sewage and the seawater. This difference will on most coasts be in the order of 15 – 25 kg/m^3. When the plume hits the surface it forms a so-called "bowl" or transition zone where the plume transforms to a co-flowing surface plume. Depending on the current in the ambient sea an upstream wedge can be formed.

A free rising plume can hydraulically seen be understood as a super critical flow with a densimetric Froude number equal to infinity, whereas the co-flowing rising plume is a sub critical flow. Accordingly the transition zone could be understood as a kind of internal hydraulic jump where a significant entrainment and dilution takes place.

In the engineering design of outfall diffusers the dilution in the transition zone where the plume turns from the rising phase to establish a buoyant co-flowing surface plume is most often neglected. The aim of this paper is to present experimental results on the dilution in this transition zone.

The experiments took place in a recirculating laboratory plume with a length of 15 m, width of 1.5 m and a water depth of 0.40 m. A number of experiments have been carried out covering various combinations of plume velocities, ambient velocities and density differences. Numerical experiments with a 3-dimensional turbulence model were carried out as well.

The author has recently argued that the need for initial dilution seems reduced because of the high demands for sewage treatment for example in Europe. A reduction in the initial dilution demands will lead to more simple and reliable design of the diffusers both in respect to proper functioning of the diffuser and to the environmental performance. The findings in this study are discussed in relation to the initial dilution demands.

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