Dilution of plunging jets used for desalination brine disposal

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Abstract We explore plunging liquid jets for disposal of reject brine from desalination plants. Compared to offshore submerged outfalls that rely on momentum to induce mixing, plunging jets released above the surface utilize both momentum and negative buoyancy. Also, plunging jets introduce air into the water column which, when dissolved, can reduce the possibility of hypoxic or anoxic zones. We measured dilution in lab experiments of both unconfined and confined plunging jets. Generally, the dilution of an unconfined jet exceeds that of a confined jet under similar conditions. However, confined jets with confining tubes which had small depth and diameter generated dilution comparable to that of an unconfined jet.

Keywords: plunging jet, desalination, brine, aeration, multiphase flow.

Motivation

Disposal of reject brine can lead to density stratification, which, in turn, can lead to development of hypoxia[1].

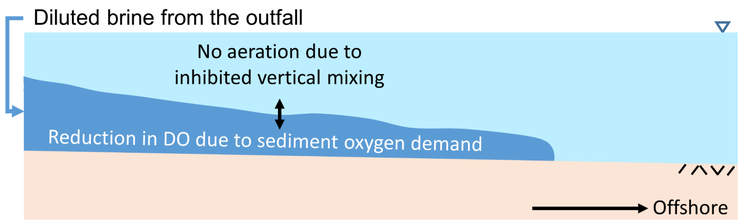

Fig. 1: Possible hypoxic zone due to brine discharge.

Studies have shown that plunging jets can increase aeration[2,3,4], but how much mixing do they provide?

Methods

- 10 psu brine discharged in 50 cm deep receiving pool.
- Fluorescent dye was added to brine and dilution was measured at the bottom of receiving pool at a radial distance of 50 cm from the nozzle.

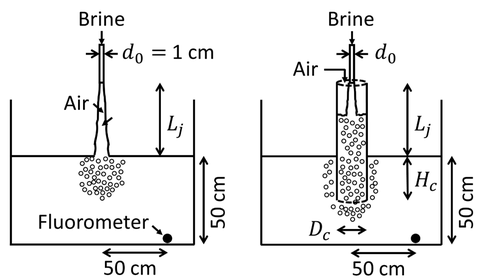

Fig. 2: Schematic showing the experimental setup for unconfined (left) and confined (right) plunging jets.

Results

Measured dilution for unconfined plunging liquid jets

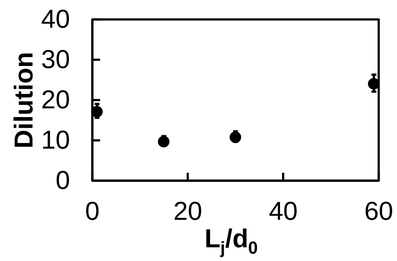

Fig. 3: Unconfined jet dilution for different jet lengths.

Measured dilution for confined plunging liquid jets

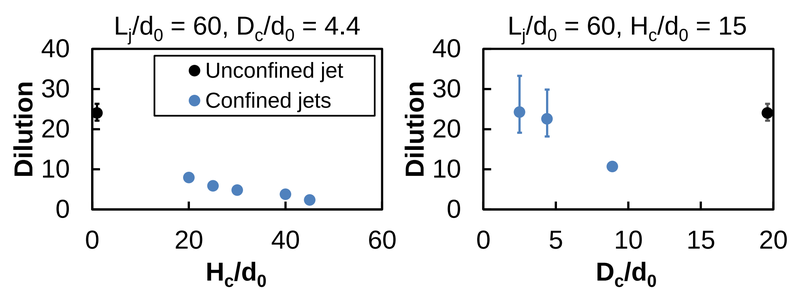

Fig. 4: Confined jet dilution as a function of the depth (left) and diameter (right) of the confining tube.

Bubble penetration depth for confined plunging jets

Fig. 5: Bubble penetration for confined jets. L_j/d_0 = 60, H_c/d_0 = 15 and D_c/d_0 = 8.9, 4.4 and 2.5 (left to right).

Conclusions

- For unconfined jets, the effect of jet length (L_j) on dilution is not monotonic with short jet lengths resulting in lower dilution than a submerged jet ($L_j = 0$).
- The presence of the confining tube around the jet limits the availability of ambient water generally resulting in lower dilution than an unconfined jet.
- Narrow confining tubes can increase bubble penetration without significantly reducing dilution.
- Bubbles are not able to escape from the bottom of a deep and wide confining tube.

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