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Rosette diffuser for dense effluent – Puck Bay case study

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ABSTRACT

Discharging wastes into natural water bodies is a common practice. The discharge systems are constructed to enhance mixing with ambient to fulfil environmental restrictions. Up till now more attention was paid to effluents characterized by density lower than ambient, e.g. discharges from treatment plants. However, diffusers discharging dense effluents require similar attention. Recently, due to construction of underground gas stores in salt deposits, brine discharge into the Puck Bay (south Baltic Sea, Poland) is on-going. The construction site is located 4 km away from the coast, while the discharge system 2300 m off-shore at a depth of 8 meters (Fig. 1). For ecological reasons, the total volume of brine is limited to 300 $m^3 h^{-1}$, while its saturation cannot exceed 250 kg m^{-3}. The water permit limits the maximum salinity to 9.2 PSU, and the excess value in the vicinity of installation to 0.5 PSU. Analysis of the discharge system carried out in the pre-investment study resulted in choice of the diffuser system of 4 arms. Each of them has 4 risers (denoted D, Fig.1) of 3 m height, spaced every 45 m. From each riser 3 nozzles of 0.009 m, distributed every 120° of circumference, discharge brine with an angle of incidence $\Theta = 45^{o}$ into the sea.

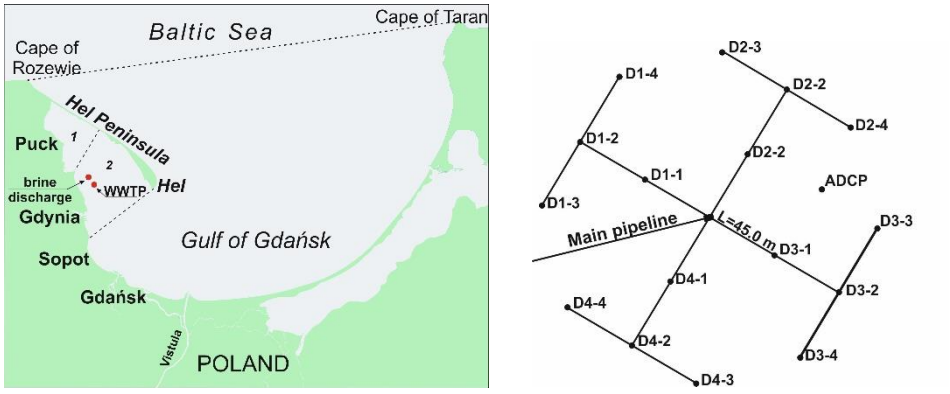

Fig. 1. Location of brine discharge in the Puck Bay (left; 1 - Puck Lagoon, 2 - Outer Puck Bay) and a general scheme of a rosette type diffuser system (right).

To control efficiency of the system, monitoring of salinity variations due to brine discharge is carried out by the system operator continuously since starting dilution of underground stores (X 2010). It covers parameters of discharge (brine saturation, discharge), salinity measurements (depths: 1.5, 3.5, 5.5, 7.5 m below MSL) in the centre of installation, and hydro-meteorological conditions (wind and water level variation) in the area of installation. Simultaneously, spatial monitoring of brine mixing in the vicinity of discharge installation, using CTD (*Conductivity Temperature Depth*) gauge, is carried out by the Institute of Hydro-Engineering Polish Academy of Sciences. In the first period (X 2010 – XII 2010) its frequency was almost once per month, while since 2015 was reduced to twice a year. In general, measurements are executed in 17 locations distributed symmetric with regard to the centre of installation, covering the area 1000 m x 1000 m. Since 2017 the scope of measurements is extended by 3 locations to analyse influence of fresh water discharge from the wastewater treatment plant (WWTP) Dębogórze on salinity pattern.

Generally, data from the on-going monitoring are sufficient to assess excess salinity for operational purposes. However, occasionally sudden salinity increase/decrease without any direct association with conditions and parameters of brine discharge, is registered. It can be expected the on-going ADCP (*Acoustic*

Doppler Current Profiler) current measurements can support their explanation. First results of ADCP measurements, started in autumn 2018, show (Fig. 2) relation between sudden salinity changes and velocity pattern.

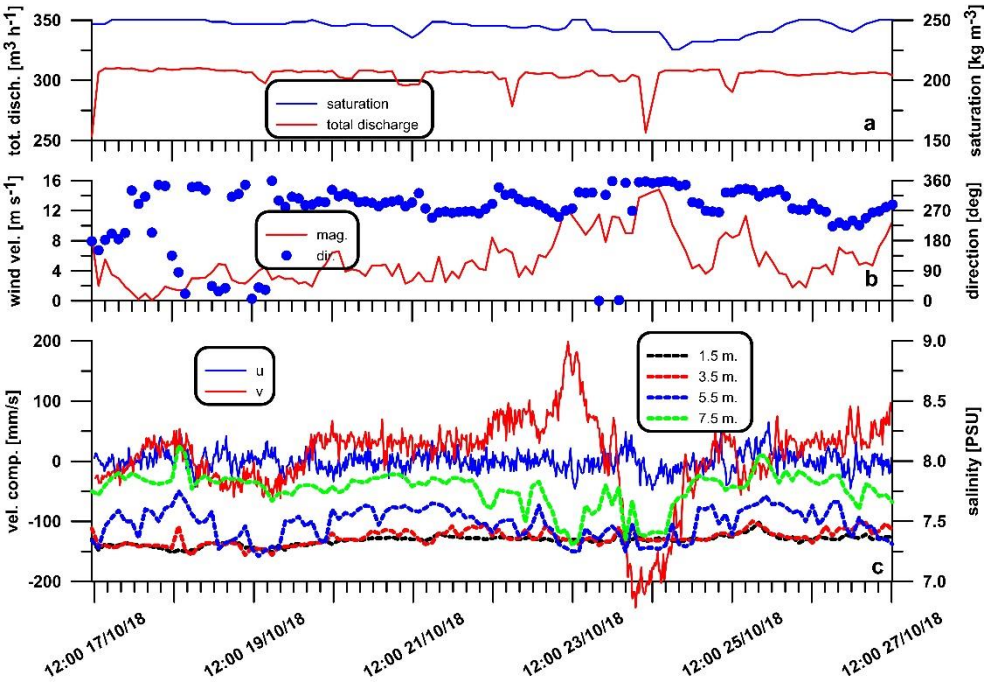

Fig. 2. Changes in the period 17-27.10.2018: a - total discharge and saturation; b – wind direction and magnitude, c - velocity components (*u, v*) in the layer 2-2.5 m above the bottom and salinity measured in the centre of installation (depths 1.5, 3.5, 5.5, 7.5 m below MSL).

The monitoring program carried out since autumn of 2010 delivers data on salinity variations in the vicinity of installation, and based on them simple operational assessment of excess salinity in majority of the year can be carried out. In complex hydro-meteorological conditions, analysis of currents measured in-situ and analysis of brine discharge conditions is recommended. Analysis of excess salinity using all available data confirms high mixing efficiency of installation, and its reduction to 0.5 PSU.

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