Hydrochemical characterization of SGD in the Bay of Puck, Southern Baltic Sea

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Introduction

Submarine groundwater discharge (SGD) is defined as all flow of water from seabed to the water column and is a significant path of both water masses and chemical substances exchange between land and ocean (Burnett et al. 2003). SGD in the Bay of Puck has been recognized as an important source of selected chemical substances in comparison to rivers, atmospheric deposition and point sources (Szymczycha and Pempkowiak 2016). The assumption was made that SGD off Hel is representative for the whole area. As inner and outer part of the Bay of Puck characterizes with different oceanographic conditions there is a need to verify whether SGD composition is similar at both parts. The aim of this study was to identify difference in SGD composition at several sites located in the Inner and Outer part of the Bay of Puck including sites located in Hel Peninsula and mainland.

Methods



The research was carried out within 2016 and 2017. Three active groundwater discharge areas were identified in Hel Peninsula (Hel, Jurata, Chałupy), and three at inland part of the bay (Puck, Swarzewo and Osłonino) based on in situ salinity measurements (Fig.1.). Samples with Cl⁻ concentration smaller than 1000 mg·dm⁻³ represented SGD, while samples with Cl⁻ concentration higher than 1000 mg·dm⁻³ were recognised as seepage water. In all collected water samples (groundwater coming from piezometers and deep wells, SGD, seepage water and seawater) several parameters: Ca^{2+} , Mg^{2+} , Na^+ , K^+ , Cl^- , SO_4^{2-} and HCO_3^- were analyzed.

Results & Discussion

Tab. 1. The concentration ranges of selected ions in SGD samples [mmol dm⁻³] in the inner part (Puck, Swarzewo, Osłonino) and in the outer part (Chałupy, Jurata, Hel) of the Bay of Puck.

Ion	Inner part		Outer part	
	min-max	median	min-max	median
Cl-	123	12	1.4-28.1	8.5
HCO ₃ -	0.1-0.6	0.4	0.01-0.34	0.01
SO ₄ ²⁻	0.1-0.2	0.1	0.14-0.15	0.14
Ca ²⁺	1.1-3.1	1.37	0.9-2.8	1.4
K+	0.3-1.5	0.6	0.1-2.2	1
Na+	75-197	77	38-194	95



Fig. 1. Map of the Bay of Puck showing the submarine groundwater discharge (SGD) sites situated in Hel Peninsula (Hel, Jurata, Chałupy) and in the continental part of the bay (Puck, Swarzewo and Osłonino), locations of piezometers and groundwater wells.



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Fig. 4. Scheme of water circulation in Hel and chloride concentration [gCl⁻·dm⁻³] in deep groundwater (GW), shallow groundwater (P), submarine groundwater discharge (SGD) and sea water (SW).

Swarzewo - gray, Puck – light blue), while particular shape represents water type (grounwater well (GW)- star, submarine groundwater discharge (SGD) - circle, seawater (SW) - square, seepage (SP) - hourglass, piezometer (P) - diamond).

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The exemplary salinity distribution in pore water located off Hel is presented at Fig.2. In areas impacted by SGD pore water salinity is lower than in seawater which was observed in every sampling site. Concentration of ions (Ca²⁺, Mg²⁺, Na⁺, K⁺, Cl⁻, SO₄²⁻, HCO₃⁻) in SGD samples in the inner part (Puck, Swarzewo, Osłonino) and in the outer part (Chałupy, Jurata, Hel) of the Bay of Puck is presented in Table 1. There is no clear separation between SGD composition in both parts of the bay. Interestingly, SGD in sites located in close proximity e.g. Hel and Jurata or Osłonino and Swarzewo were comparable (Fig. 3), comprising the fact that SGD composition depend on SGD provenance or/and factors influencing SGD like e.g. land-use, precipitation and storms etc. Sites located in outer part of the bay and at the same time at the Hel Peninsula are under strong influence of land-sea interactions represented by both storms and seawater intrusion. Thus, groundwater located at shallow watersheds and as a consequence SGD can become slightly saline (Fig. 4). The preliminary results suggest that SGD composition varies, can depend on the groundwater provenance and, surely, land-water interactions. Moreover, the Bay of Puck seems to be great area for multidisciplinary studies of SGD due to its varius oceanographic features and, therefore, we plan to continue our invetigations devoted to factors inluencng SGD in this area.

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Baltic Sea Region



