NITROGEN AND PHOSPHORUS COMPOUNDS IN COSTAL AQUIFERS IN PUCK MUNICIPALITY AREA (NORTHERN POLAND)

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This study shows preliminary results of investigation of nutrients (nitrogen and phosphorus compounds) in a coastal multi-aquifer groundwater system in the Puck Municipality area (northern Poland) and their potential impact on seawater quality in Puck Bay.

The investigation area is mostly used for agriculture and forestry. It is covered by young glacial sediments. The landscape consists of moraine uplands and deeply cut ice marginal valleys (Sokołowski, 2014). Groundwater occurs in a form of small perched aquifers (**Pa**) on top of glacial till, and two main Quaternary aquifers (**Q1** and **Q2**). Groundwater flow is directed to Puck Bay, where submarine groundwater discharge (SGD) takes place. The SGD ocures about 1-5 km from the coast, where the aquifer outcrops are located in the sea bottom of Puck Bay (Jankowska et.al., 1994).

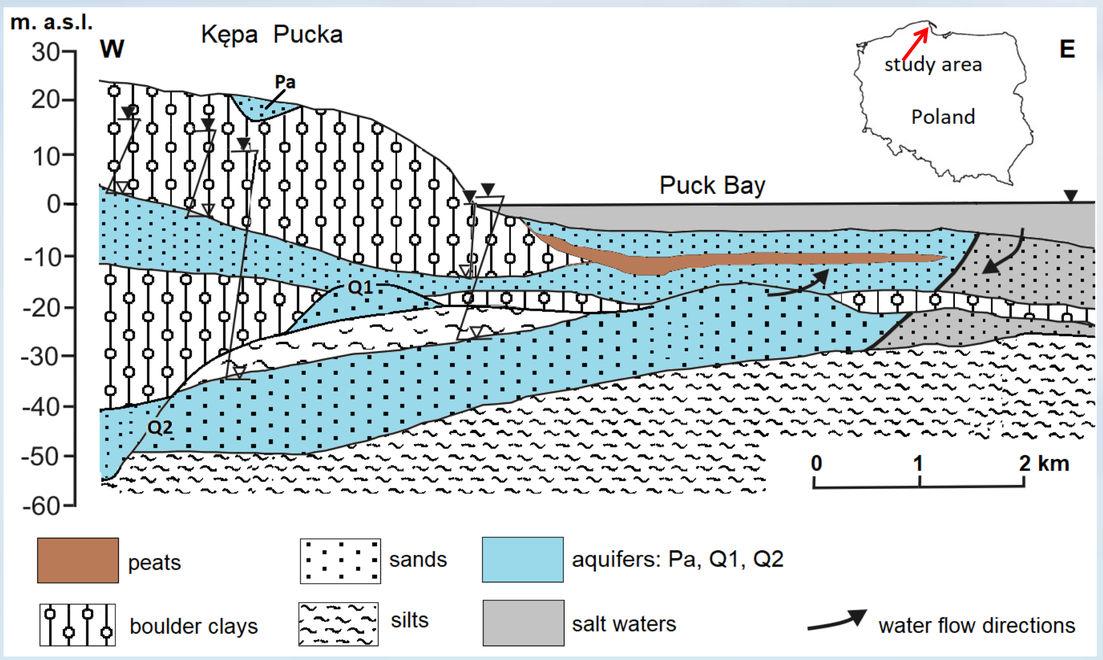


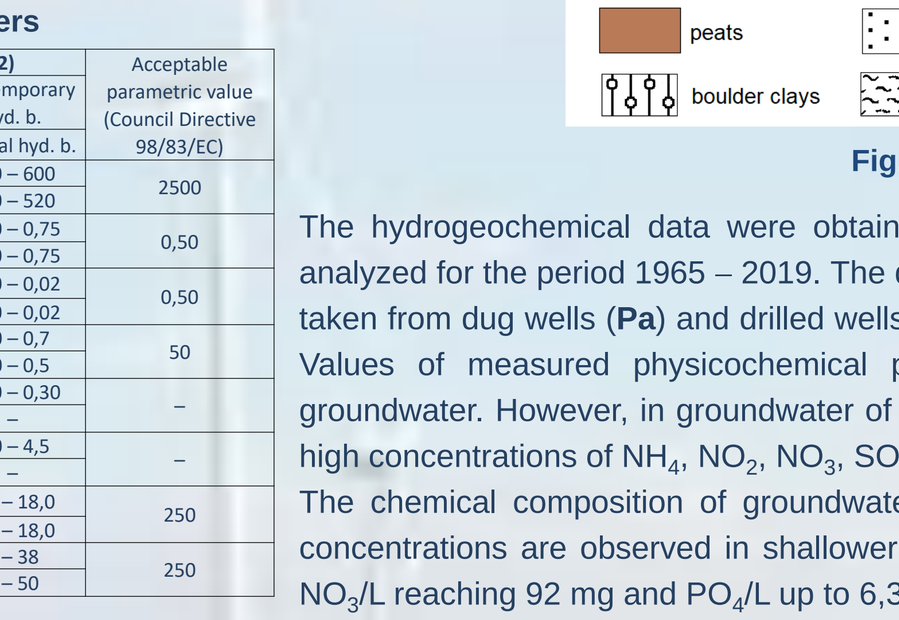
Fig. 1. Hydrogeological cross-section

Table 1. Chemical composition of groundwaters

	Perched aquifer (Pa)		Shallow aquifer (Q1)		Deep aquifer (Q2)		Acceptable parametric value (Council Directive 98/83/EC)
	MIN – MAX	Contemporary hyd. b.	MIN – MAX	Contemporary hyd. b.	MIN – MAX	Contemporary hyd. b.	
	MEDIAN	Natural hyd. b.	MEDIAN	Natural hyd. b.	MEDIAN	Natural hyd. b.	
EC [µS/cm]	124 – 1346	300 – 570	244 – 1012	370 – 870	279 – 680	320 – 600	2500
	491	–	572	380 – 620	432	380 – 520	
NH_4 [mg/L]	0,005 – 0,435	0,00 – 0,10	0,001 – 3,32	0,00 – 0,2	0,005 – 0,97	0,00 – 0,75	0,50
	0,028	–	0,030	0,00 – 0,3	0,175	0,00 – 0,75	
NO_2 [mg/L]	<0,01 – 0,67	0,00 – 0,04	<0,01 – 0,42	0,00 – 0,02	<0,01 – 0,09	0,00 – 0,02	0,50
	0,04	–	0,01	0,00 – 0,01	<0,01	0,00 – 0,02	
NO_3 [mg/L]	2,0 – 49,0	30 – 22,0	<0,1 – 92,0	0,0 – 2,5	<0,1 – 2,6	0,0 – 0,7	50
	25,9	–	10,0	0,0 – 2,0	0,3	0,0 – 0,5	
PO_4 [mg/L]	0,16 – 6,38	0,15 – 0,75	0,10 – 3,06	0,10 – 0,5	0,09 – 0,67	0,10 – 0,30	–
	0,50	–	0,37	–	0,18	–	
K [mg/L]	1,05 – 119,4	0,0 – 6,0	1,40 – 7,02	0,0 – 6,0	0,6 – 3,5	0,0 – 4,5	–
	9,10	–	2,10	–	2,01	–	
Cl [mg/L]	1,4 – 158,0	2,0 – 22,0	2,3 – 92,0	5,0 – 55,0	1,0 – 21,3	2,5 – 18,0	250
	13,2	–	14,0	5,0 – 35,0	7,4	5,0 – 18,0	
SO_4 [mg/L]	5,0 – 89,0	5 – 60	2,0 – 156,0	5 – 55	4,0 – 143,0	2 – 38	250
	28,5	–	44,9	0 – 35	17,0	0 – 50	

The hydrogeochemical data were obtained from field surveys and archival data and were analyzed for the period 1965 – 2019. The differences in chemical composition of water samples taken from dug wells (**Pa**) and drilled wells, boreholes and springs (**Q1** and **Q2**) are noticeable. Values of measured physicochemical parameters in **Q2** aquifer are typical for natural groundwater. However, in groundwater of **Pa** and **Q1** aquifers pollutions were found (relatively high concentrations of NH_4, NO_2, NO_3, SO_4, K and Cl – Tab.1).

The chemical composition of groundwater depends on the depth of its occurrence. Higher concentrations are observed in shallower aquifers **Pa** and **Q1** (EC (PEW) up to 1012 µS/cm, NO_3/L reaching 92 mg and PO_4/L up to 6,38 mg))(Fig. 2, Tab.1).



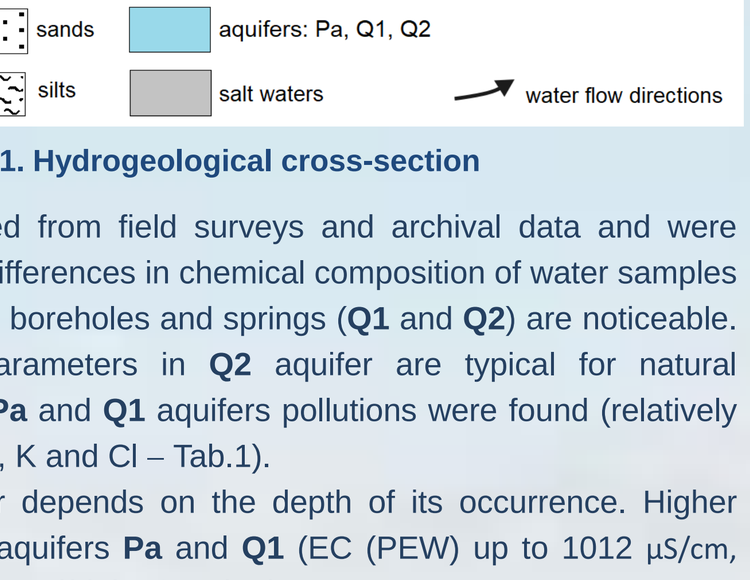


Fig. 2. Dependence of the chemical composition and depth of the groundwater below the ground level

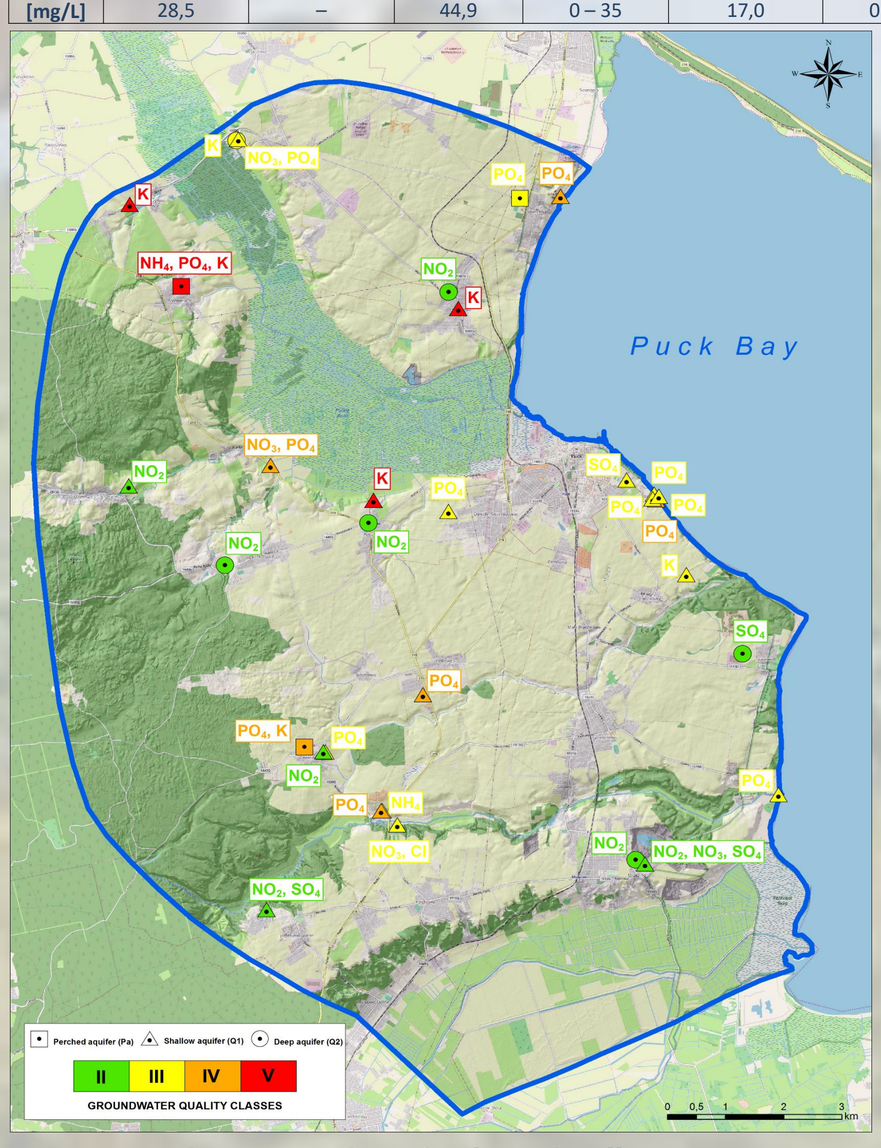


Fig. 4. Location of selected pollutant indicators in groundwater

Variation of groundwater chemical composition in time is significant, especially in shallow aquifers (**Pa**, **Q1)**. Currently, we observe higher concentrations and larger range of hydrogeochemical background of the analyzed parameters than in previous years (Tab.1., Fig. 3).

Local character of the pollution is noticeable in analysis of the sample locations (Fig. 4). Agricultural land use can be a potential source of the contamination. Besides nutrients (nitrogen and phosphorus compounds), in some locations we found high concentrations of SO_4, Cl and NH_4 ions, which may indicate domestic and farm pollution (Macioszczyk, 1987).

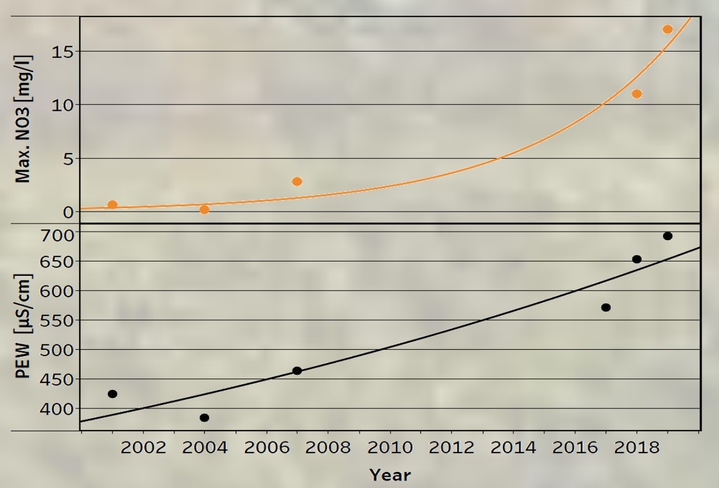


Fig. 3. Variation of groundwater chemical composition (Q1 aquifer) in time

CONCLUSIONS

1. Groundwater study shows local variations in chemical composition of selected aquifers caused by human impact. The diversity is mainly manifested in:
   - time variation of groundwater chemical composition of all analyzed parameters, especially in shalow aquifers (Pa, Q1),
   - relationship between the groundwater chemical composition and depth of the aquifer, where an inverse concentration distribution occurs - higher concentrations are observed in shallow aquifers (Pa and Q1),
   - mosaic spatial distribution of the pollution indicators, which means pollution has a local character caused by anthropogenic activity.
2. Composition of the basic pollution indicators in groundwater shows local impact of agriculture, as well as contamination from households and farms, which can potentially influence the quality of water in Puck Bay via SGD. This is a subject of ongoing research.

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