HYDROGEOCHEMICAL CHARACTERISTICS AND INTERPRETATION OF GAUJA AQUIFER IN LATVIA

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INTRODUCTION

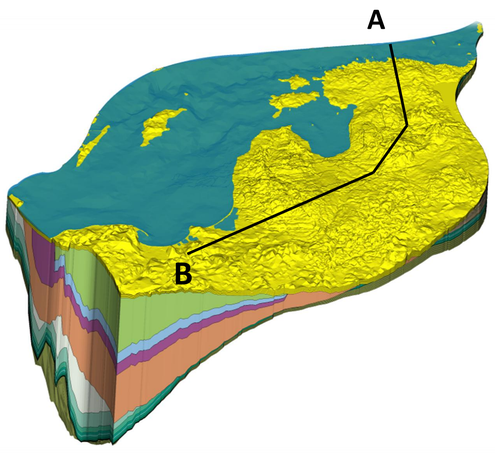


Figure 1. **Extent of the Baltic Artesian Basin and the study area**

The territory of Latvia is a part of the Baltic Artesian (Sedimentary) basin which considering water chemistry and water exchange intensity between aquifers can be divided into three major zones:

- **freshwater** (active water exchange) with mineralisation <1g/l,
- **saline** (delayed exchange) with mineralisation 1-30g/l,
- **brines** (passive water exchange zone) with mineralisation >30g/l.

Latvia is rich with groundwater resources of various chemical composition, therefore groundwater is the main drinking water source. Nevertheless, groundwater quality can be easily affected by pollution or overexploitation (for example, the formation of Riga depression cone in early 60's and negative affect on groundwater quality of Gauja (D3gj) aquifer).

Generally trace elements are present in small quantities in low mineralised, unpolluted groundwater. On the one hand many trace elements are biologically essential and their deficiency can cause disorders or even illnesses, on the other hand some of them can become toxic when reach certain levels.

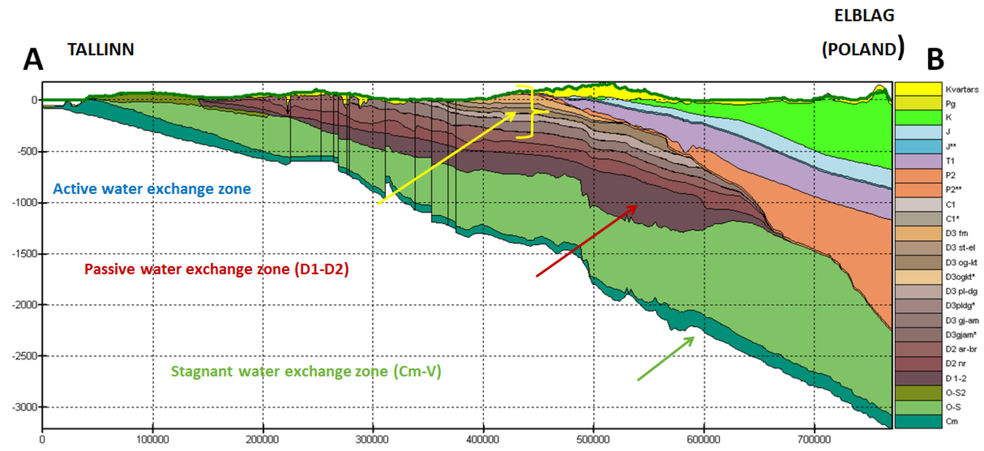


Figure 2. **Cross- section of the Baltic Artesian Basin across Latvia territory**

MATERIALS AND METHODS

The data on groundwater physical and chemical properties including trace element data from the previous studies (Levins and Gosk, 2007) were analyzed for the first time along with the new groundwater monitoring results in 2013 and the data collected from water supply wells during the groundwater prospect prior investigation (period 1998-2013).

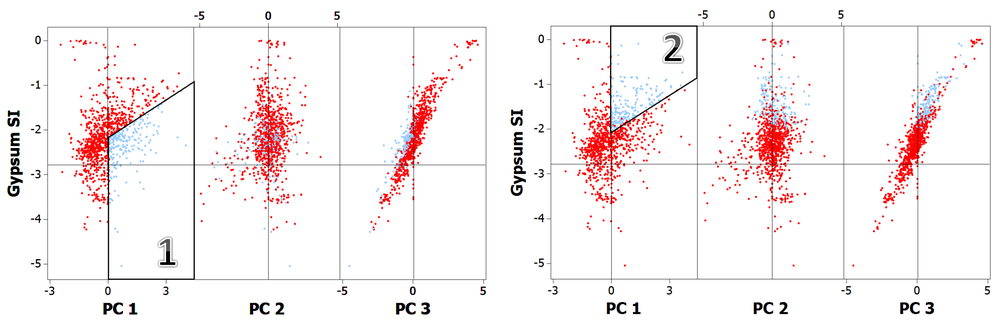
Principal component analysis (PCA) with Varimax rotation was performed using SPSS 19. The data who did not meet normal distribution was normalised. A preliminary cleaning of the data set included removal of strong outliers, variables with a poor reproducibility and variables with missing data more than 30% (including non-detects). The observations below detection limit (<DL) were substituted with 50% of DL. Ionic balance and saturation index were calculated using PHREEQC.

AIM OF THE STUDY

The aim of the study was to determine the geological processes affecting the quality of groundwater in Latvia in aquifers mainly used for water supply. And to distribute groups with different trace elemnet content.

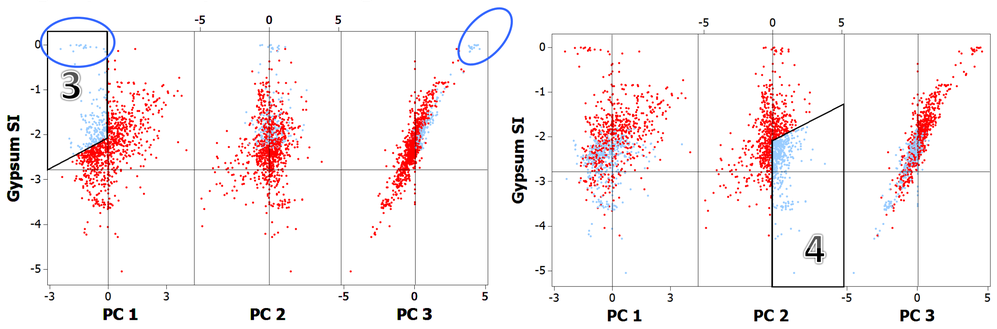
Most of studies on trace element content in aquifer systems concentrate on anthropogenic pollution and there are no large studies about the natural baseline concentrations of trace elements in Latvia.

RESULTS



1.group describe groundwater with positive loading of PC1 and negative loading of PC3.

2.group describe positive loading of PC1 and PC3.



3.group describe negative loading of PC1 and positive loading of PC3.

4.group describe positive loading of PC2 and negative loading of PC3.

5.group describe negative loading of PC1,PC2 and PC3. This group does not belong to any of PC obtained by PCA.

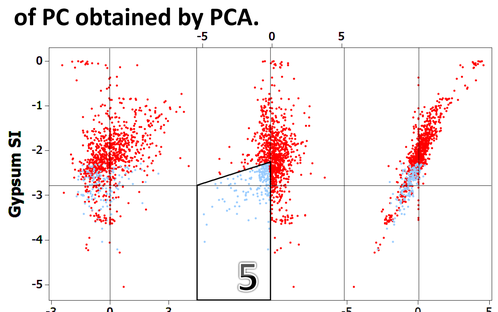


Figure 3. **Groundwater groups distributed from PCA results.**

Ca-SO4 water type with high TDS from Salaspils (D3slp) aquifer with gypsum minerals present.

The first five PC explains 75,4% of total variance of the data set presented in Table 1.

PC 1 shows strong positive loadings of Halite SI, Na, Cl, K, Mg. Component describes saline groundwater or groundwater with Cl ion as dominant anion formed by mixing with deeper, more mineralised water or sea water (more rarely). Positive loading of Gypsum SI and SO4 indicate the samples from deeper aquifers with both, high Cl and SO4 content.

PC 2 shows strond positive loadings of Ca, Mg, HCO3 and strong negative loading of Calcite SI and Dolomite SI. Component reflect the most common Ca-Mg-HCO3 water type with Dolomite and Calcite SI close to zero. Positive loading of F can be explained as Ca-Mg-HCO3 water mixing with Ca-SO4 water or as indicator of other F source aside from gypsum.

PC 3 shows strong positive loadings of Ca, Gypsum, SO4 and positive loadings of Mg and F. Coponent describes Ca-SO_4 water type formed by gypsum dissolution. F is present in secondary minerals of evaporites.

Table 1

Rotated Component Matrix*

	Component		
	1	2	3
Halite SI	**,941**	,141	,173
Na	**,911**	,175	,077
Cl	**,858**	,058	,236
K	**,649**	,114	,206
Mg	**,544**	**,503**	**,385**
Calcite SI	-,091	**-,910**	-,090
Dolomite SI	-,178	**-,897**	-,028
HCO3	,168	**,784**	,069
Ca	,159	**,651**	**,607**
Gypsum SI	**,336**	,130	**,915**
So4	**,379**	-,022	**,889**
F	-,028	**,334**	**,339**

*Rotation Method: Varimax with Kaiser Normalization

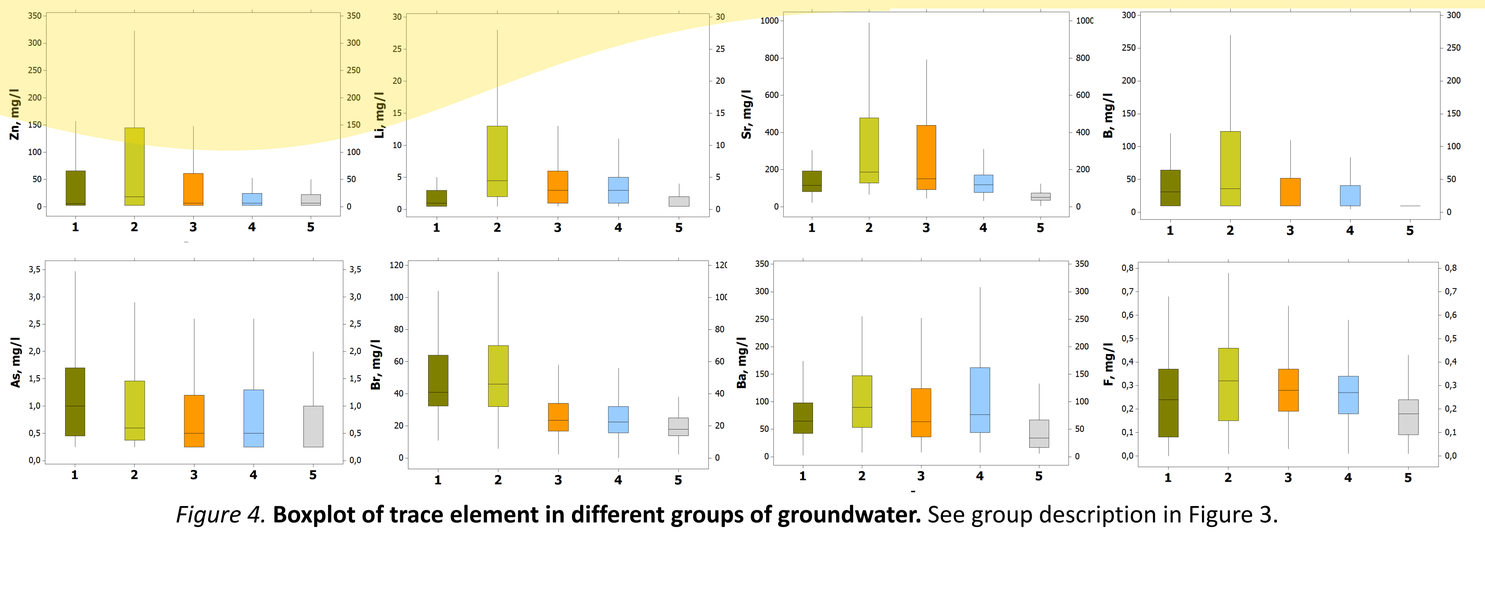


Figure 4. **Boxplot of trace element in different groups of groundwater.** See group description in Figure 3.

SUMMARY

- **The results from PCA show that there are three main water types and processes affecting groundwater quality:**
  1) **Groundwater mixing with saline groundwater from deeper aquifers or in lesser extent with sea water;**
  2) **The most common Ca-Mg-HCO3 water type with Calcite SI and Dolomite SI close to zero;**
  3) **Ca-SO4 water type formed by gypsum dissolution.**
- **The highest Zn, Li, Sr, B, Br and F concentrations can be found in SO4 and Cl rich waters in distributed group 2 where PC1>0 and PC3>0. The group mainly includes samples from Gauja (D3gj) aquifer and contains samples from aquifers affected by sea water intrusion.**
- **Group 5 mainly describes medium mineralised, unpolluted Ca-Mg-HCO3 waters from Arukila (D2ar), D3gj and Q aquifers were PC1, PC2 and PC3 show negative loadings. Depth is typically less than 80m.**
- **Group 1 describes Na-Cl, Ca-Mg-HCO3(Cl) and typical Ca-Mg-HCO3 water types with low to medium TDS where PC1>0 and PC3<0. The group mainly contains samples from Q and D3gj aquifer and show the highest As concentration, also elevated Br, B and Sr concentration.**
- **Group 3 describes SO4 rich groundwater with elevated Zn, Li, Sr and F concentration with high TDS where PC1<0 and PC3>0. Group mainly contains samples from Q, Plavinu (D3pl) and Salaspils(D3slp) aquifers.**
- **Group 4 describe the most common Ca-Mg-HCO3 water type with medium Zn, Li, Ba and F concentrations. Previous studies suggest that main F source is gypsum dissolution, but the results show that there is probably another source in carbonate sediments. The group contains samples from all active water exchange zone aquifers, includin D3gj aquifer.**

Acknowledgement

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