FOKS

Focus on Key Sources of Environmental Risks

RISK-BASED APPROACH TO ASSESSMENT OF GROUNDWATER POLLUTION

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FOKS project - receptors

In the FOKS project the relevant bodies of groundwater are considered as the receptors

FOKS risk criteria

- National-specific **groundwater threshold values** (GTVs) defined for assessing ”good chemical status” of a groundwater body by individual EU Member States; they depend on the national groundwater protection level

Risk-based groundwater pollution assessment method

Classification of measuring points (piezometers, wells) into groups representing different potential pollution sources and calculation of a groundwater pollution risk index (GRI)

Risk-based groundwater pollution assessment - steps

- Identifying and selecting pollutants which potentially contribute to the pollution of the relevant body of groundwater (based on archived monitoring data and/or preliminary site assessment taking into consideration a type of industrial activities)

- Classifying groundwater measuring points into groups representing different potential sources of gw body pollution (based on the conceptual hydrological site model)

Risk-based groundwater pollution assessment - steps

- Gathering investigation data (concentrations of pollutants) by the measuring points
- Calculating the average pollutant concentrations (GC) within each group of measuring points

Risk-based groundwater pollution assessment - steps

- Comparing the GC calculated within each group with the relevant national-specific GTV; calculation of **groundwater pollutant-specific risk quotients - GRQ:**

$$GRQ_{ij} = \frac{GC_{ij}}{GTV}$$

Risk-based groundwater pollution assessment - steps

- Calculating **groundwater pollution risk index** (**GRI)** for each group of measuring points:

$$GRI_j = \sum_{i=1}^{n} GRI_{ij}$$

Risk-based groundwater pollution assessment - steps

- Ranking of the calculated GRI values
- Identifying the key groundwater pollution sources by the GRI values
- Calculating the contribution of each pollutant to the entire GRI value in each group of measuring points

Risk-based groundwater pollution assessment - steps

- Prioritising the pollutants in each group of measuring points
- Ranking the pollutants by the GRQ values; categorising the pollutants as of low, medium or high priority on the basis of the relevant GTV exceedance degree

Risk-based groundwater pollution assessment – pollutant categories

- **Low priority pollutants** - average GRQ_A are below or equal 1 ($GRQ_A <= 1$) in all measuring points
- **Medium priority pollutants** - average concentrations exceed their respective GTVs less than 10 times ($1 < GRQ_A <= 10$)
- **High priority pollutants** - average concentrations exceed their respective GTVs more than 10 times ($10 < GRQ_A$)

Jaworzno pilot site – pollutants of interest

- **Organic pollutants:**

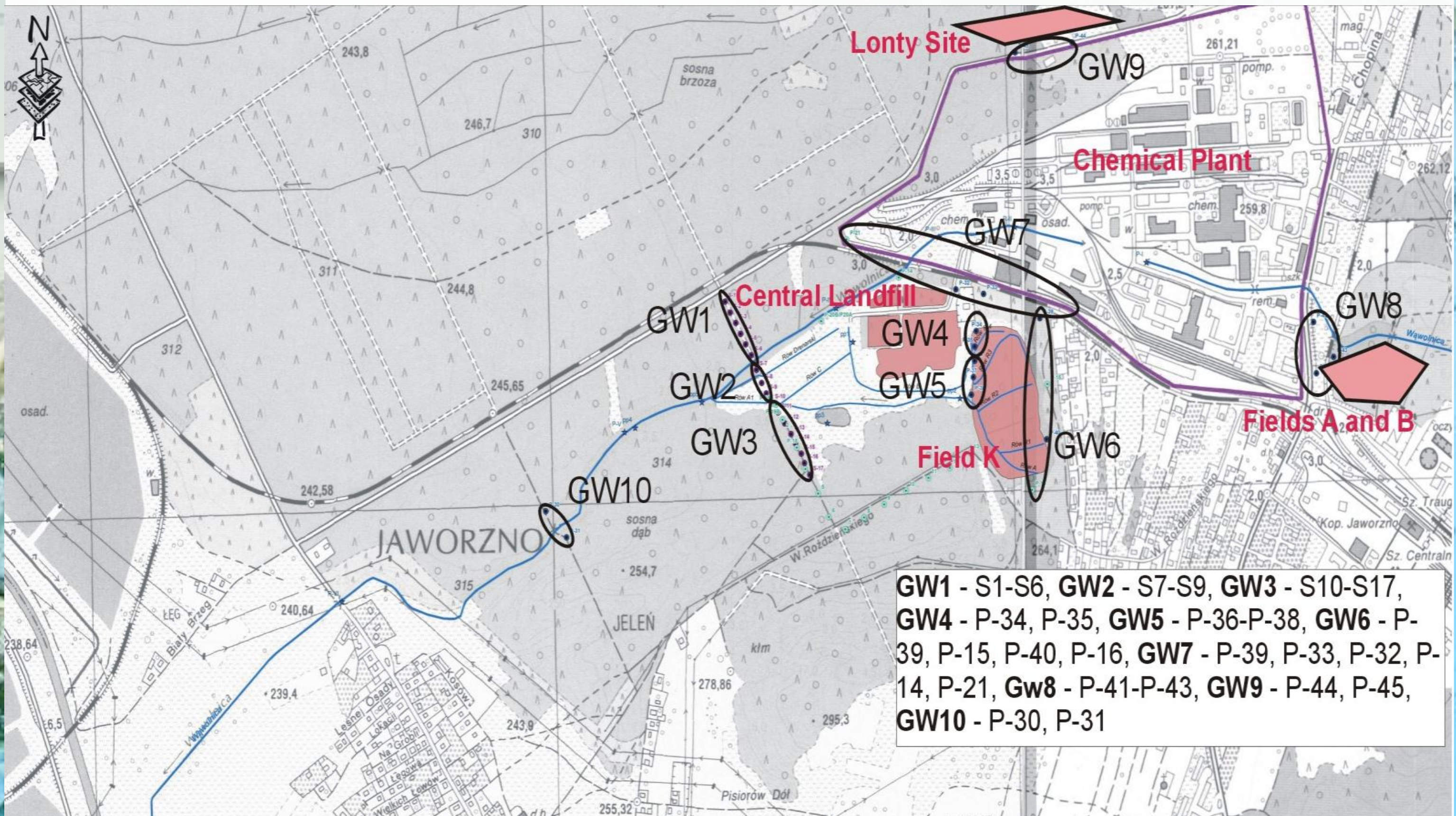
  hydrocarbons C10-C40, phenols, Σchlorobenzenes, PCE, TCE, BETX, ΣVHH; pesticides: HCH, DDT, DDE, DDD, aldrin, dieldrin, endrin, tetradifon, chlordane, mirex, heptachlor

- **Inorganic pollutants:**

  As, B, Cr, Zn, Cd, Cu, Ni, Pb, Hg, V, Ca, Mg, Na, K, Fe, Mn, amonium ions, chlorides, sulfates, fluorides, nitrates, nitrites, bicarbonates, cyanides (free)

(Polish GTVs were applied for most of the Jaworzno site pollutants; German GTVs were applied for Σchlorobenzenes and ΣVHH)

Jaworzno pilot site – groups of groundwater measuring points



Field A

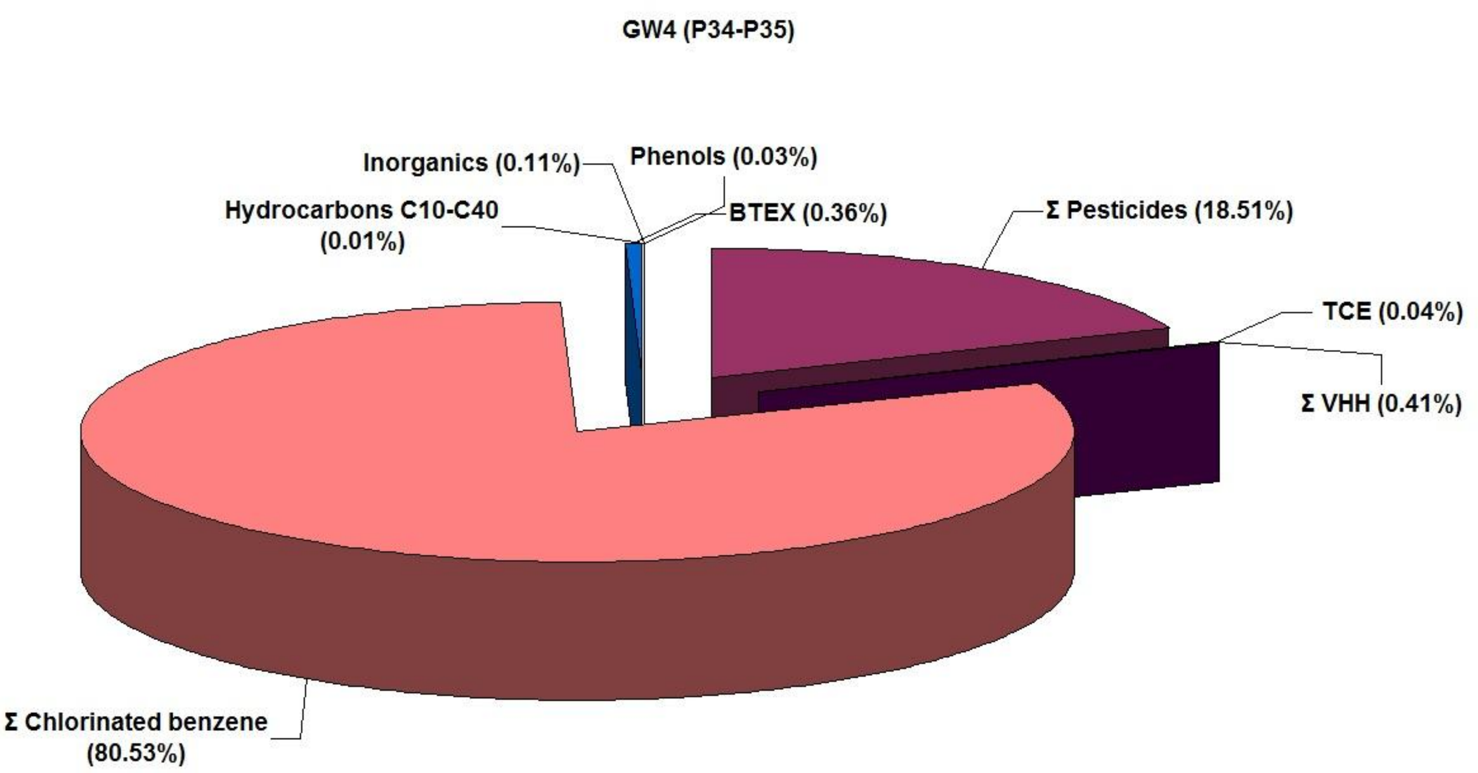
RA results - ranking GRIs

Groups of measuring points		GRI
GW4	P34-P35	39709.78
GW7	P39, P33, P32, P14, P21	7898.43
GW3	S10-S17	2867.30
GW6	P39,P15,P40,P16	1276.15
GW1	S1-S6	568.89
GW10	P30-P31	310.99
GW5	P36-P38	284.02
GW2	S7-S9	132.89
GW8	P41-P43	55.15
GW9	P44-P45	33.53

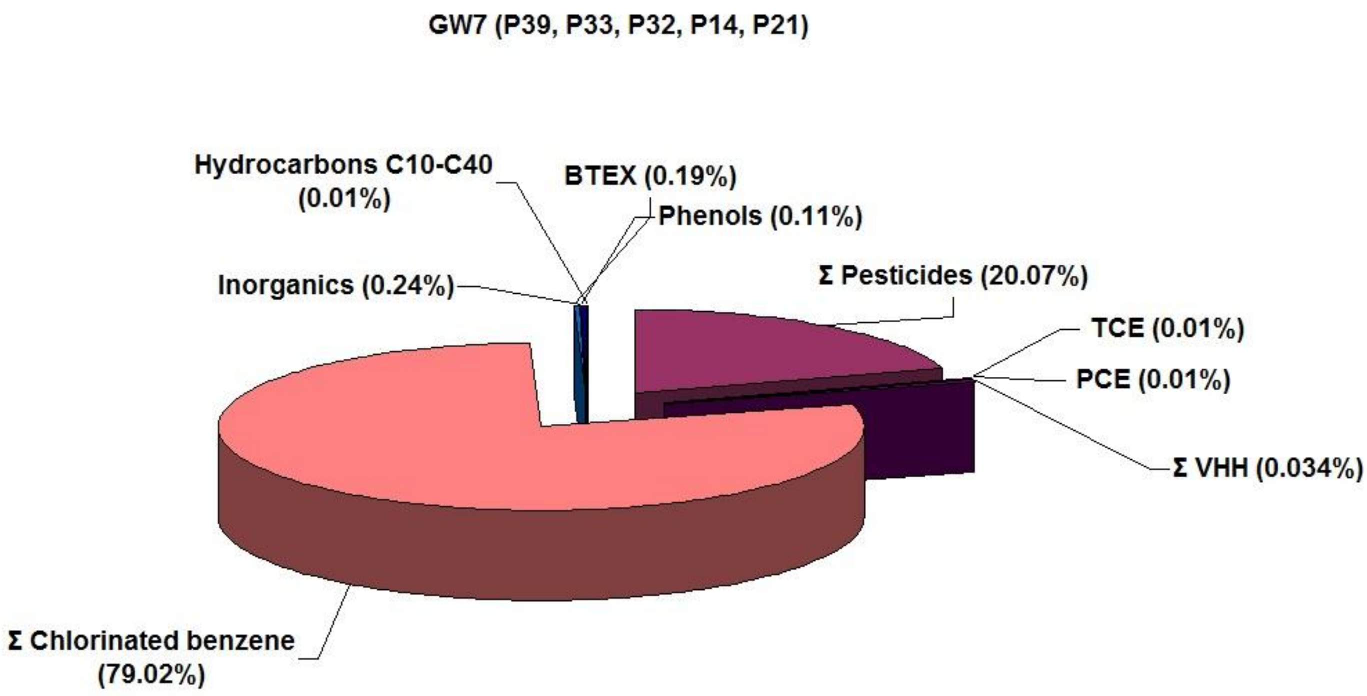
RA results - GRQs for pollutants in the highest priority GW4, GW7, GW3

	Groups of measuring points		
Pollutant	GW4	GW7	GW3
	GRQ		
C10-C40	3,67	1,17	0,17
Pesticides	7348,60	1585,06	2125,43
PCE	1,90	0,42	0,08
TCE	15,53	0,97	0,47
VHHs	163,69	27,16	3,10
Chlorinated benzenes	31980,00	6241,42	719,52
BTEX	141,79	14,87	2,35
Phenols	10,50	8,30	2,83
Inorganics	44,11	19,07	13,36
GRI	**39709,78**	**7898,43**	**2867,30**

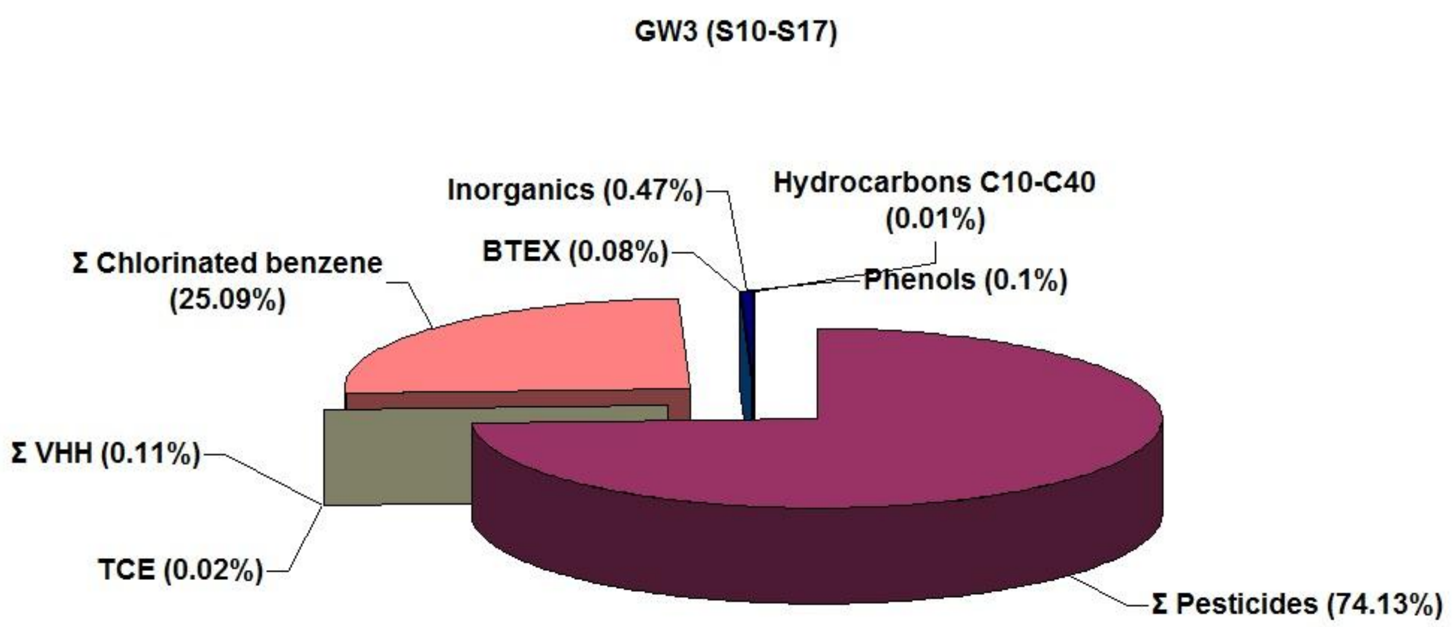
RA results – contribution of pollutants to the highest priority GRIs



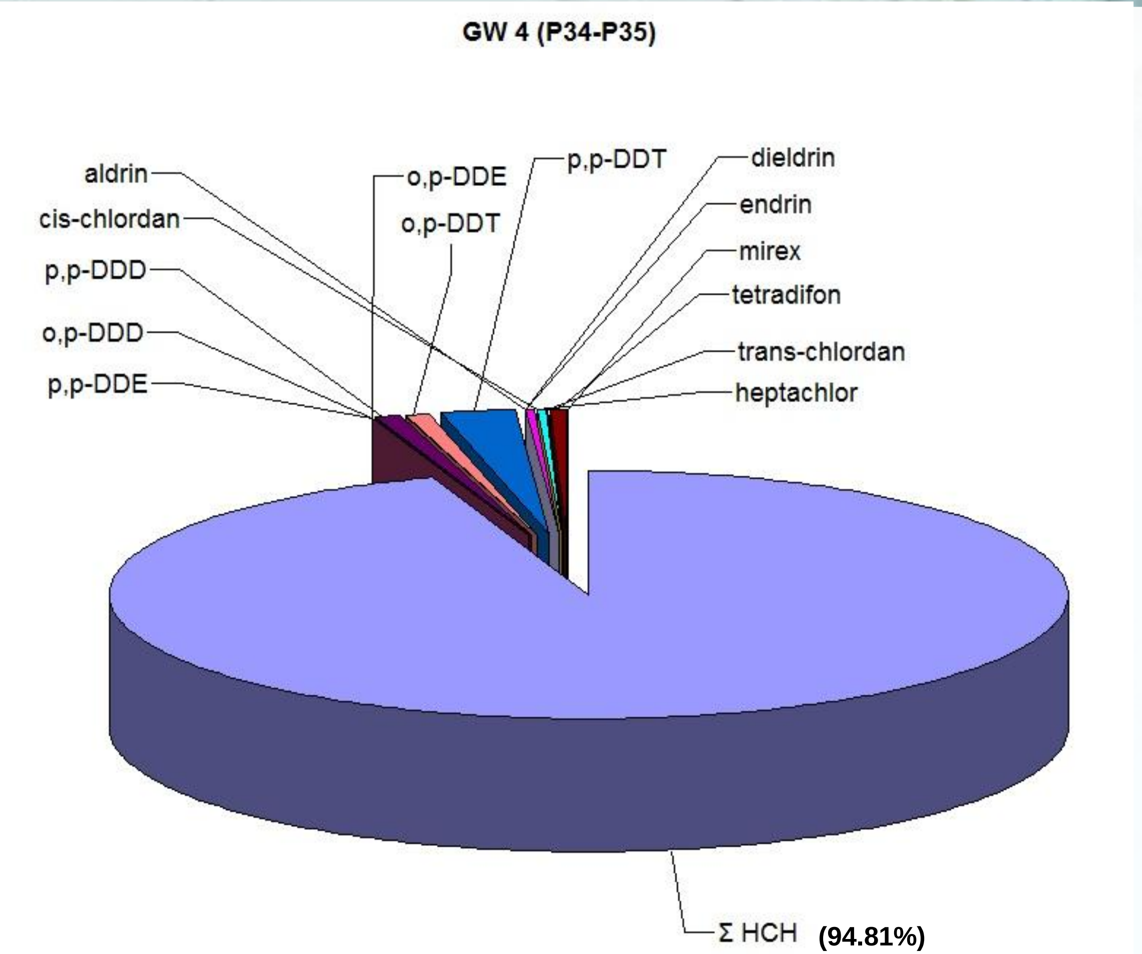
RA results – contribution of pollutants to the highest priority GRIs



RA results – contribution of pollutants to the highest priority GRIs



RA results – HCH contribution to pesticide GRQ

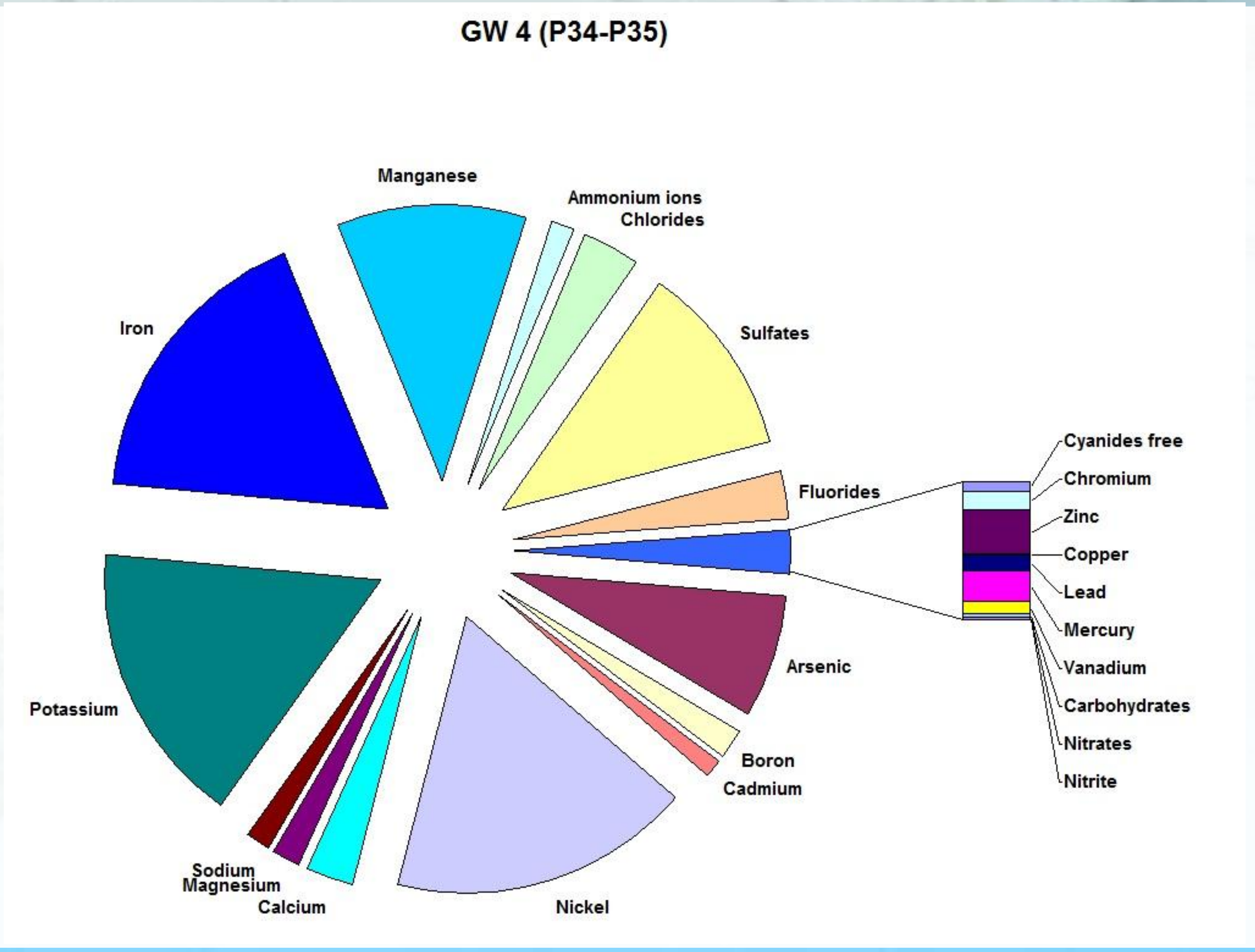


HCHs - above 90% in GW3, GW1, GW7, GW4, GW10

RA results – HCH isomers contribution to HCH GRQ

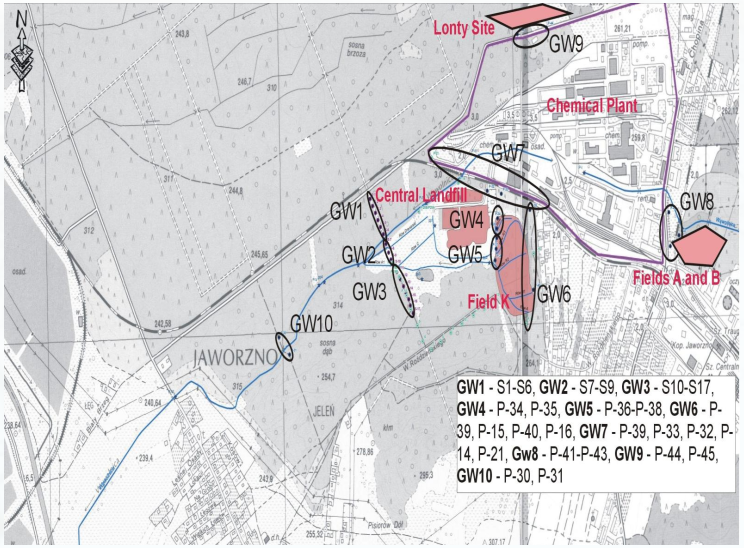
Groups of measuring points		HCH isomers contribution to HCH GRQ (%)			
		alfa-HCH	beta-HCH	gama-HCH	delta-HCH
GW1	S1-S6	23,44	54,27	14,91	7,38
GW2	S7-S9	15,34	14,18	6,50	63,97
GW3	S10-S17	8,27	1,32	15,71	74,70
GW4	P34-P35	22,60	3,05	39,90	34,45
GW5	P36-P38	14,82	24,94	13,10	47,14
GW6	P39,P15,P40,P16	20,92	15,42	8,18	55,48
GW7	P39, P33, P32, P14, P21	35,30	7,58	12,11	45,01
GW8	P41-P43	27,33	30,37	10,63	31,67
GW9	P44-P45	12,23	57,34	5,35	25,08
GW10	P30-P31	4,79	5,55	0,94	88,72

RA results – contribution of inorganic pollutants to inorganic GRQ



Preliminary conclusions

- The highest GRI values were obtained for GW4 and GW7 groups of measuring points. They amount to about 40000 and 8000 for GW4 and GW7, respectively.



These results indicate that Field K (N part) and sources located at the Chemical Plant should be considered as groundwater pollution sources of the first priority.

Preliminary conclusions

- Chlorinated benzenes contributed the most to the entire GRI values in both GW4 and GW7 groups (about 80 %).
- Central Landfill (SE part) can be considered as a pollution source of the second priority; the GRI value for GW3 group, which represents this source, amounts to about 3000; the 3rd position in ranked GRI values.
- Pesticides contributed the most to the entire GRI values in GW3 (about 74%); chlorinated benzenes – about 25%.

Preliminary conclusions

- HCHs contributed the most to the entire pesticide GRQ values in all established groups of measuring points; above 90% in GW3, GW1, GW7, GW4, GW10.

- Among HCH isomers γ-HCH was the dominant isomer in most established groups of the measuring points;

  β-HCH was the dominant isomer only in GW1 and GW9,

  δ-HCH - only in GW4.

- The lowest GRI values were obtained for GW9 and GW8 groups of measuring points. These results indicate that Lonty Site and Fields A&B should be considered as pollution sources of the lowest importance.

Risk assessment objectives

- suport the identification of the pollution sources representing the highest risk to the relevant body of groundwater / surface water
- prioritise pollutants
- identify pollutants that may require further evaluation (pollutants of high and medium priority)

Risk assessment objectives

- complement mass flux (load)-based approach and other FOKS tools applied for identification of key sources of water pollution
- support the selection of appropriate remedial options / mitigation measures
- support monitoring and assessment of the effectiveness of selected remedial options