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# **Quality of bank filtrated water in different locations of wells**





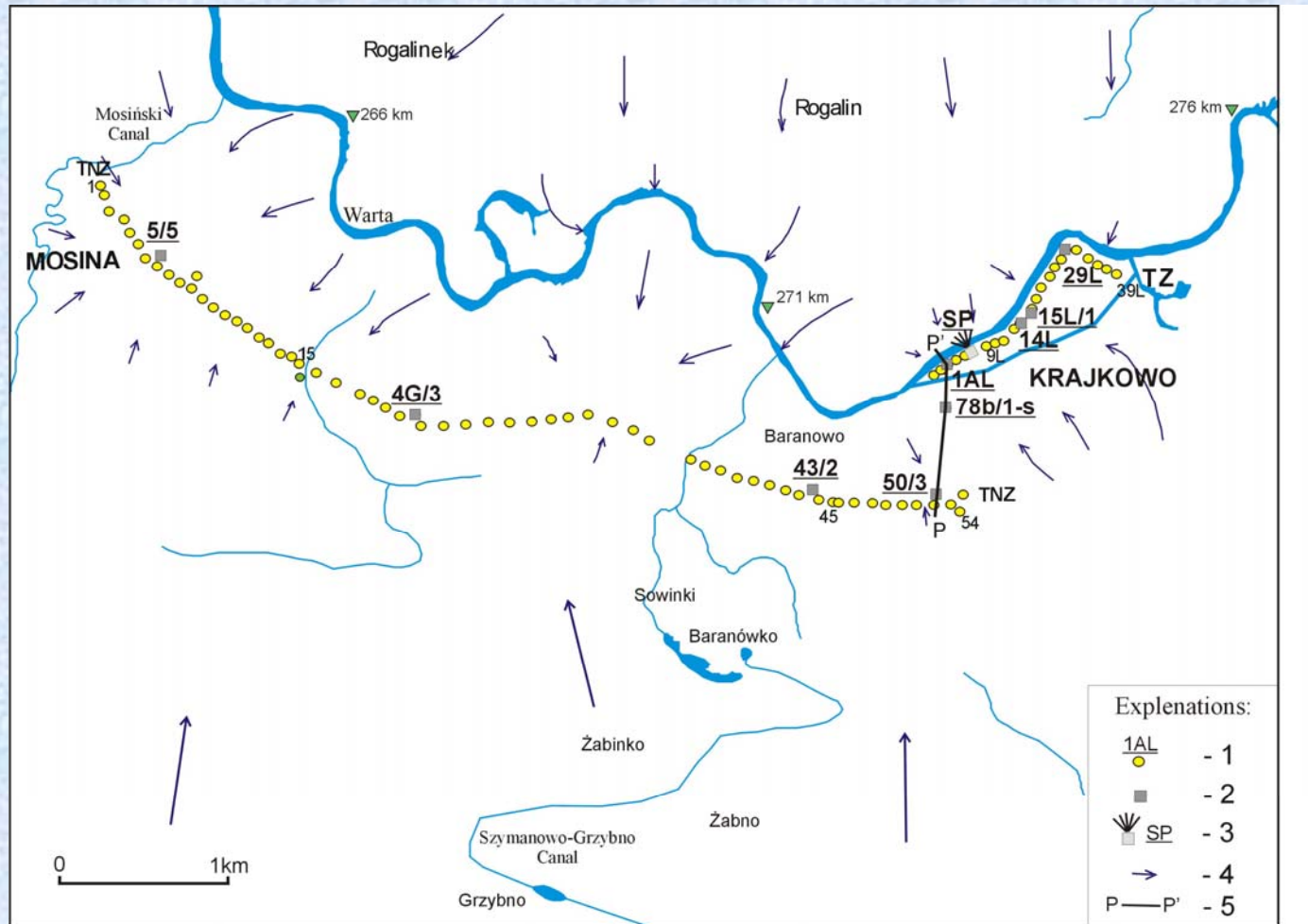
Warta River in Puszczykowo

## **Investigation aim**

Determination of water quality changes depending on well location as regards a river including ground and river water participation in well recharge

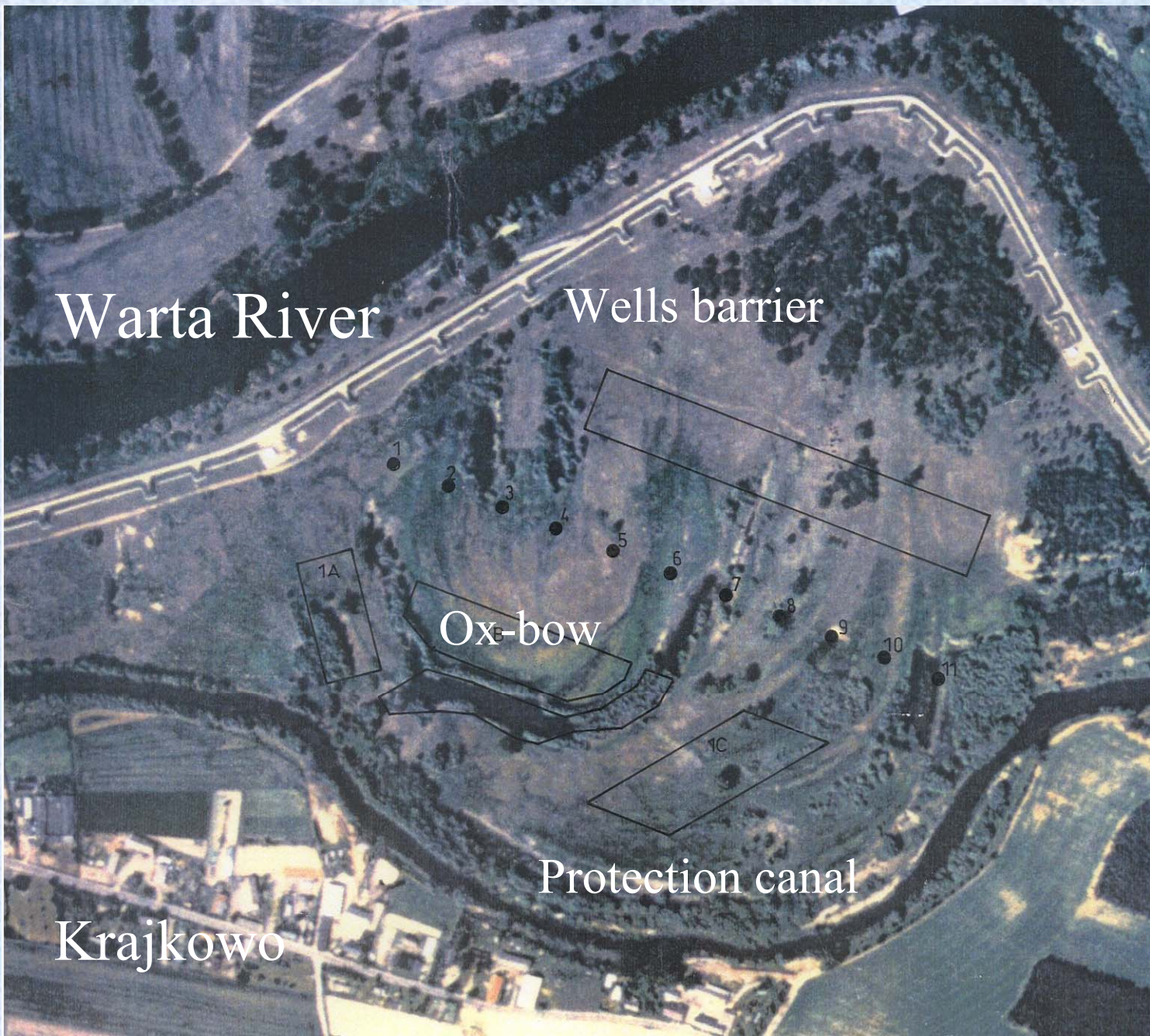


# Characteristic of the Mosina-Krajkowo water work



**Fig. 1. Sketch of the Mosina-Krajkowo wellfield with location of the investigation sites**  
 1 – drilled wells, 2 – observation wells, 3 – drainage well, 4 – direction of ground water flow, 5 – hydrogeological cross-section





Warta River

Wells barrier

Ox-bow

Protection canal

Krajkowo

1

2

3

4

5

6

7

8

9

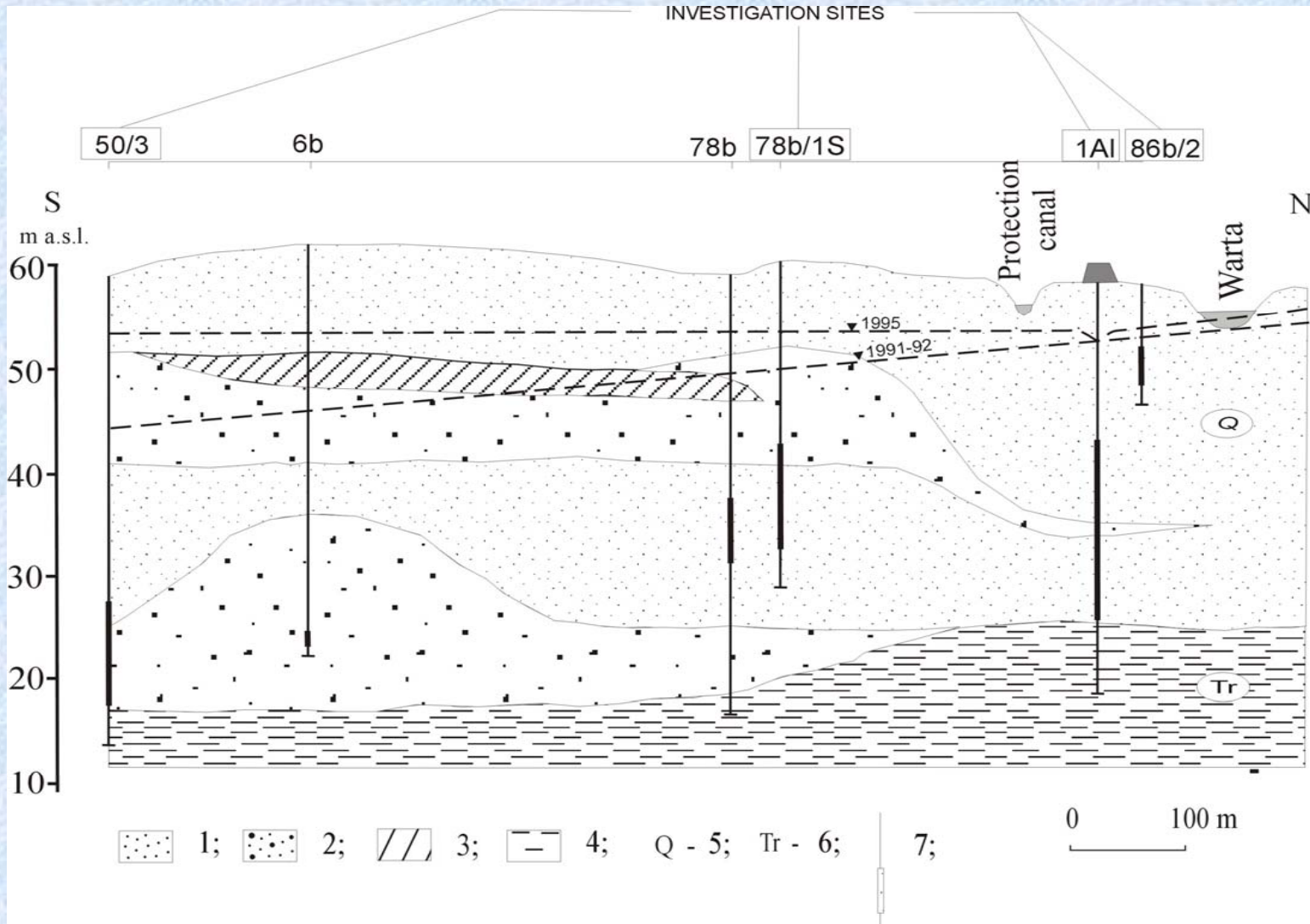
10

11

1A

1C





**Fig. 2. Hydrogeological cross-section over the investigation sites in Krajkowo**  
 1 – fine and medium sands, 2 - coarse sands, gravels, 3 – glacial tills, 4 – clays, 5 – Quaternary deposits, 6 – Tertiary deposits, 7 – well screen

# Investigation sites

- Warta River
- drainage well in the river bed
- 4 vertical wells located at the distance of 70-80 m from the river
- 4 vertical wells located at the distance of 480-1100 m from the river
- 1 observation well located at the distance of 30 m from the river
- 1 observation well located at the distance of 250 m from the river

**Table 1. Characteristic of the investigation sites and the results of hydrogeochemical and hydrobiological investigations (October 1996 – June 1998)**

**A. Characteristic of the investigation sites**

Investigation sites	Morphology	Distance from:		Depth of the well screen at [m]	Participation of infiltrating water in well recharge [%]
		River [m]	Flood plain edge [m]		
<b>Warta</b>	River bed	-	-	-	-
<b>Drainage well</b>	Drains under the river bed	0	-	5 m below the river bottom	up to 100
<b>86 b/2</b>	By the river	30	-	6,0-10,0	90
<b>1 AL</b>	Flood plain	70	-	16,1-33,6	80
<b>14 L</b>	Flood plain	70	-	15,8-33,4	75
<b>15 L/1</b>	Flood plain	70	-	16,8-35,8	75
<b>29 L</b>	Flood plain	80	-	18,0-35,0	85
<b>78 b/s</b>	Higher terrace	250	30	18,0-28,0	60
<b>50/3</b>	Higher terrace	750	500	31,8-41,8	60
<b>43/2</b>	Higher terrace	480	480	32,1-47,1	50
<b>4 G/3</b>	Higher terrace	800	800	23,0-36,0	50
<b>5/5</b>	Higher terrace	1100	150	30,0-45,0	60



# Methodology

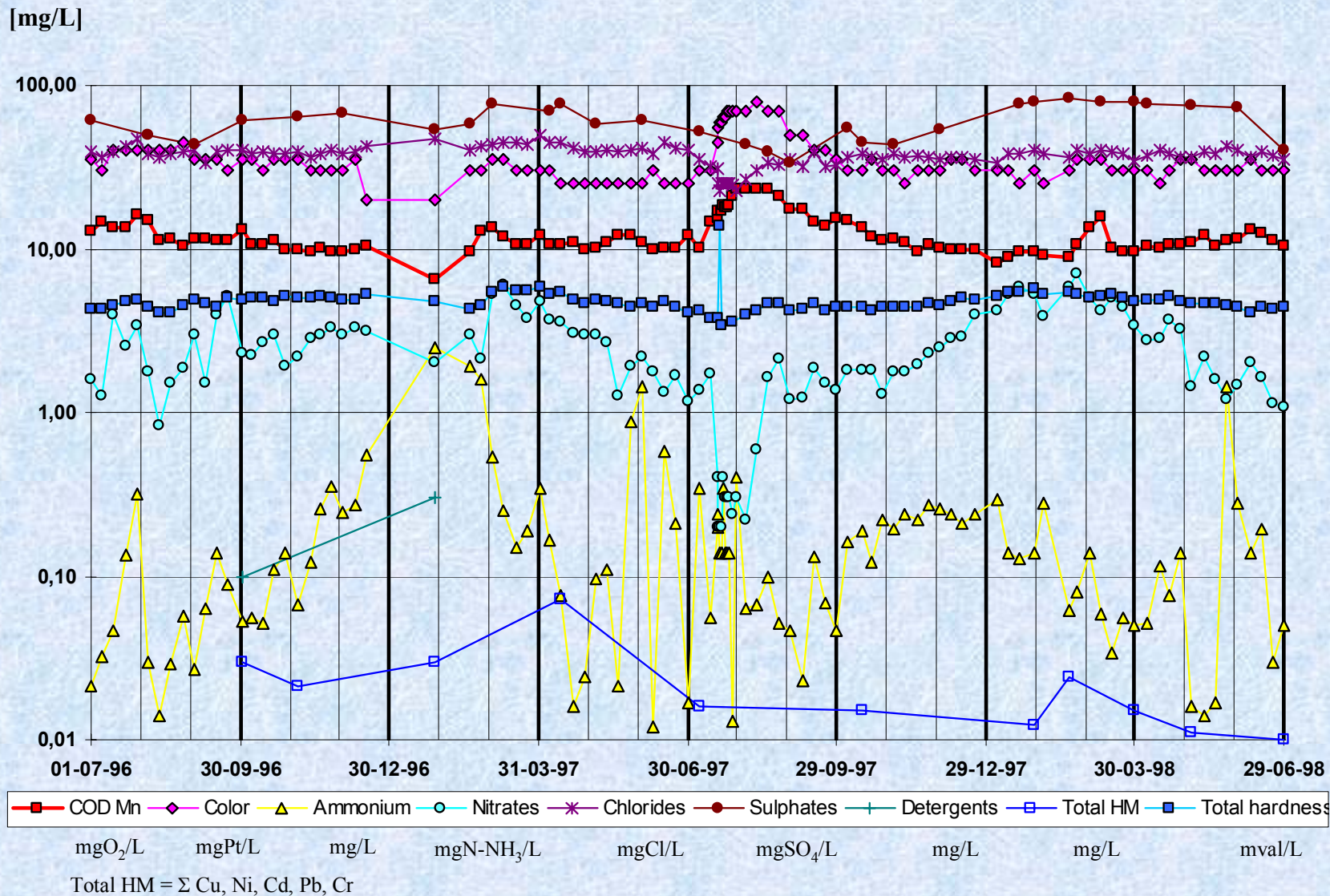
## Measurements:

- water level
- wells yield
- physicochemical analyses in the range of: temperature, smell, color, pH,  $\text{NH}_4$ ,  $\text{NO}_2$ ,  $\text{NO}_3$ , Fe, Mn, Cl,  $\text{SO}_4$ , hardness,  $\text{COD}_{\text{Mn}}$  and  $\text{COD}_{\text{Cr}}$  alkalinity,  $\text{O}_2$ ,  $\text{BOD}_5$ , TOC, phenols,  $\text{PO}_4$ , dry residue, Na, K, Mg, Ca,  $\text{N}_{\text{org}}$ ,  $\text{H}_2\text{S}$ , detergents, Pb, Zn, Cd,  $\text{Cr}_{\text{org}}$ ,  $\text{Cr}^{6+}$ , Ni, dichloromethane, chloroform, 1,2-dichloroethane, carbon tetrachloride, trichloroethylene, 1,2-trichloroethane, tetrachloroethylene as well as hexachlorobenzene, heptachlor and its epoxide, DDT, pentachlorophenol, PAH, aromatic and aliphatic hydrocarbons.

➤ bacteriological analyses: coliform bacteria, amount of bacteria culture at the temperature of 37°C and 20°C

➤ hydrobiological analyses: plankton





**Fig. 3. Chart presenting water quality of the Warta River**

# Results and discussion

**Table 1. Characteristic of the investigation sites and the results of hydrogeochemical and hydrobiological investigations (October 1996 – June 1998)**

## B. Chosen indicators of water quality

Investigation sites	Water quality indicators									
	Fe [mg/l]		Mn [mg/l]		COD <sub>Mn</sub> [mgO <sub>2</sub> /l]		COD <sub>Cr</sub> [mgO <sub>2</sub> /l]		Sulphates [mg/l]	
	max	average	max	average	max	average	max	average	max	average
Warta	0,93	0,58	0,30	0,15	13,4	10,0	38,6	24,1	79,8	60,9
Drainage well	0,34	0,15	0,43	0,18	7,7	6,1	22,8	13,3	86,8	70,72
86 b/2	0,19	0,11	1,25	0,40	6,9	5,9	28,7	20,5	78,2	61,3
1 AL	1,09	0,95	0,67	0,59	7,8	5,4	27,1	19,6	76,1	66,5
14 L	1,32	0,86	0,59	0,49	7,6	5,7	27,7	19,7	90,5	71,5
15 L/1	1,67	1,20	0,69	0,49	7,3	5,9	40,0	22,6	89,7	71,9
29 L	1,36	0,63	0,59	0,53	5,1	4,8	18,6	15,5	81,1	69,1
78 b/s	1,42	1,31	0,74	0,62	5,3	4,8	18,8	15,3	74,9	68,8
50/3	4,28	3,25	0,38	0,32	4,8	4,3	27,7	13,9	207,4	127,6
43/2	5,57	5,20	0,34	0,32	6,6	6,2	20,0	14,0	155,1	122,4
4 G/3	4,56	3,96	0,54	0,44	5,5	4,8	27,6	14,1	119,7	109,7
5/5	7,22	6,69	0,52	0,52	5,0	4,5	11,8	8,8	137,0	116,9



## C. Chosen indicators of water quality

Investigation sites	Water quality indicators								Plankton organisms
	NH <sub>4</sub> [mg/l]		NO <sub>3</sub> [mg/l]		Detergents [mg/l]		Coliform bacteria		amount [in 1 ml of water]
	max	average	max	average	max	%	max	%	
Warta	2,49	0,23	7,07	2,47	0,30	61	700000	100	very numerous
Drainage well	2,46	0,18	7,11	2,28	0,15	17	1 670	52	single organisms
86 b/2	1,28	0,28	4,19	1,97	0,20	33	398	75	14
1 AL	0,78	0,45	2,22	0,90	0,06	12	5	17	0
14 L	0,40	0,19	2,01	0,42	0,10	25	1	14	64
15 L/1	0,40	0,20	1,46	0,32	0	0	0	0	single organisms
29 L	0,16	0,28	1,64	0,74	0,20	50	5	40	single organisms
78 b/s	0,34	0,18	0,25	0,07	0	0	0	0	single organisms
50/3	0,53	0,43	0,05	0,03	0,05	12	0	0	0
43/2	0,54	0,37	0,07	0,05	0	0	0	0	a few organisms remains
4 G/3	0,76	0,53	0,05	0,04	0,03	12	0	0	a few organisms remains
5/5	0,34	0,24	0,07	0,05	0	0	0	0	a few organisms remains

% percentage of the analyses with detected contamination

# Drainage well and piezometer 86/b/2

- water similar to the water of the Warta River in the range of: sulphates, nitrates, detergents, chlorides
- reduction of bacteria, plankton and oxidability but bacteriological contamination and plankton occurrence observed
- water enrichment with Mn during its filtration through 5 m thick sediments of the river bed
- temperature range: 0°C - 25°C
- water quality from the drainage well particularly unfavorable: during melt water runoffs, in the periods of long-lasting river ice-sheet cover, during floods, after debris movements above well drains (bacteriology, color and manganese)



# **Wells at the distance of 70-80 m from the river**

- the influence of the river water in the range of nitrates, organic matter and detergents but the significant reduction of these parameters by sorption and heterotrophic denitrification processes
- periodical occurrence of the bacteriological contamination, plankton and some micropollutants
- water enrichment with Mn, Fe, Ca and Mg
- temperature range: 5-15°C to 25°C during the flood period
- clogging of the river bed sediments caused by an intensive exploitation in drought period

# **Observation well located 250 m from the river**

- the influence of the river water in the range of nitrates, oxidability and detergents almost not observed
- no bacteriological contamination



# Well barrier at the distance of 480-1100 m from the river

- water composition typical for ground water
- the influence of the river water in the range of nitrates and micropollutants not observed
- the influence of the river water reflected by the increased contents of organic matter and hydrogen sulphide
- ground water quality deterioration in the range of Fe, Mn,  $\text{SO}_4$  and hardness induced by sulphides and organic matter oxidation during exploitation

# Conclusions

1. The investigations showed that in the conditions of significant surface water contamination, the bank wellfields close to a river (<50 m) and the wellfields located within bed sediments are inappropriate from the point of view of water quality. Wellfields of these types are also unfavorable because of the significant influence of the extreme hydrological stages on water quality and the exploitation conditions (clogging)

2. Wells located at the distance of 70-80 m to the river showed the considerable influence of the river on the quality of the exploited water. Its symptoms are: bacteria, plankton as well as micropollutants and nitrates. Water quality from the well no. 78b/s located 250 m from the river is much better than water quality from the bank wells and is similar to the typical ground water



3. The influence of the river in the range of nitrates and micropollutants is not observed in case of the terrace wells located 480-1100 m from the river. A composition of the exploited water is typical for ground water, however, soil and ground water medium are enriched with organic matter. The result of it is the increased oxidability and the occurrence of sulphides and plankton remains

4. On the basis of the carried research it was found that the wells should be located 150 m to 250 m from the river in order to obtain favorable quality of the exploited water. Such distance assures ground water residence time of at least 6 months

5. The investigations showed that the bank infiltration has induced unfavorable changes of hydrogeochemical environment even in case the wells located considerably far from the river (500-1100m). This phenomenon points out that the best solution of river water exploitation through the infiltration would be the artificial one. This solution limits also the soil enrichment with organic matter



**Thank you for your attention!**