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ESTIMATION OF THE QUALITY OF GROUND WATERS PROVIDED FOR THE WATER-SUPPLY SYSTEM IN THE AREA OF GOGOLIN COMMUNE

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OCENA JAKOŚCI WÓD PODZIEMNYCH UJMOWANYCH DO SIECI WODOCIĄGOWYCH NA OBSZARZE GMINY GOGOLIN

Badania próbek wody pochodzących z ujęć wodociągowych 10 miast miały na celu ocenę jakości wód podziemnych na obszarze gminy Gogolin. Zmiany 17 parametrów składu fizyczno-chemicznego wód analizowano zgodnie z polskimi standardami. Jakość wód podziemnych oszacowano na podstawie porównania uzyskanych wyników zarówno z wartościami granicznymi Polskich Norm dla wody do picia, jak i z kryteriami klasyfikacji zwykłych wód podziemnych na potrzeby monitoringu. Stwierdzono, że wody pobrane z każdego ujęcia spełniają wymagania stawiane wodom przeznaczonym do picia i na potrzeby gospodarcze. Stężenia większości parametrów wskazywały na wody najwyższej (klasa Ia) i wysokiej (klasa Ib) jakości. Zaobserwowano także wpływ czynników antropogenicznych na stan czystości wód podziemnych. Sporadyczne przekroczenia wartości granicznych odnotowano dla następujących wskaźników: azotu azotanowego – max. o 50% w Obrowcu i 20% w Choruli, siarczanów – 19% w Kamieniu Śląskim, żelaza – 100% w Górażdżach.

Summary

Water samples collected from the water-supply system of ten towns were examined in order to evaluate the ground water quality in the commune of Gogolin. The changes of 17 parameters of water composition and water quality were determined by analytical methods described in Polish Standards. The quality of ground waters was estimated by comparing the results obtained with both limit values for drinking water in Poland and criteria of classification of ordinary ground waters according to Polish State Environmental Monitoring. It was found that ground water from each of the investigated water intake met all the requirements set for drinking water and household purposes (with few exceptions). The concentrations of most of the parameters determined within the research indicated waters of the highest (class Ia) and high quality (class Ib). However, influence

of anthropogenic factors was also marked on water purity. The limit value of the following parameters was occasionally exceeded: nitrate nitrogen – max. by 50% in Obrowiec and 20% in Chorula, sulphates – by 19% in Kamień Śląski, iron – by 100% in Górażdże.

INTRODUCTION

In the area of Opole Voivodeship only water-supply systems of Brzeg, Głuchołazy and Nysa are provided with surface waters, whereas population of the other towns is supplied by municipal or factory ground water intakes. The main part in creation of ground water resources in the region of Gogolin commune is taken by Triassic formations. The commune area is situated within the range of four reservoirs of ground waters, which occur in formations of lower and middle sandstone, ret, Gogolin layers and schelly limestone. Only the range of the reservoir surging in water-bearing formations of shelly limestone does not comprise the whole area of commune, as its souther border lies on the level of the following village administrative units: Malnia, Górażdże, Kamionek and Kamień Śląski. The reservoir is also not exploited because of low unit efficiency from well inlets which equals to $0.36-3.6$ m^3/h [2, 4]. Thus, the essential and useful significance have the remaining water-bearing levels, from which water is drawn by nineteen drilled wells of depth $58-250$ m and max. working capacity $21-120$ m^3/h. Those intakes supply water for all the village administrative units in the commune area through the water-supply system. In order to remove excessive amounts of iron and manganese compounds, water is subjected to water treatment processes before providing it to the network.

On account of the fact that ground waters are the only source of drinking water, fundamental importance for assurance of their adequate quality has the constant control of water quality and water protection. This research aimed at:

– estimation of water quality from the water-supply system in the area of Gogolin commune,

– recognition of the influence of potentail sources of ground water pollution.

METHODOLOGY

Water samples for analyses of physical-chemical water composition were collected from ten intakes of the water-supply system, selected within the area of Gogolin commune in the following towns: Chorula, Dąbrówka, Gogolin, Górażdże, Kamień Śląski, Kamionek, Malnia, Obrowiec, Odrowąż and Zakrzów (Fig. 1). The researches were carried out in the years $1996-1997$, when the samples were taken once a month in summer season (June – August).

Electrical conductivity and pH were measured immediately on site. Laboratory physical-chemical analysis of water aimed at determination – according to Polish Standards – of the other fifteen variables which included: hardness,

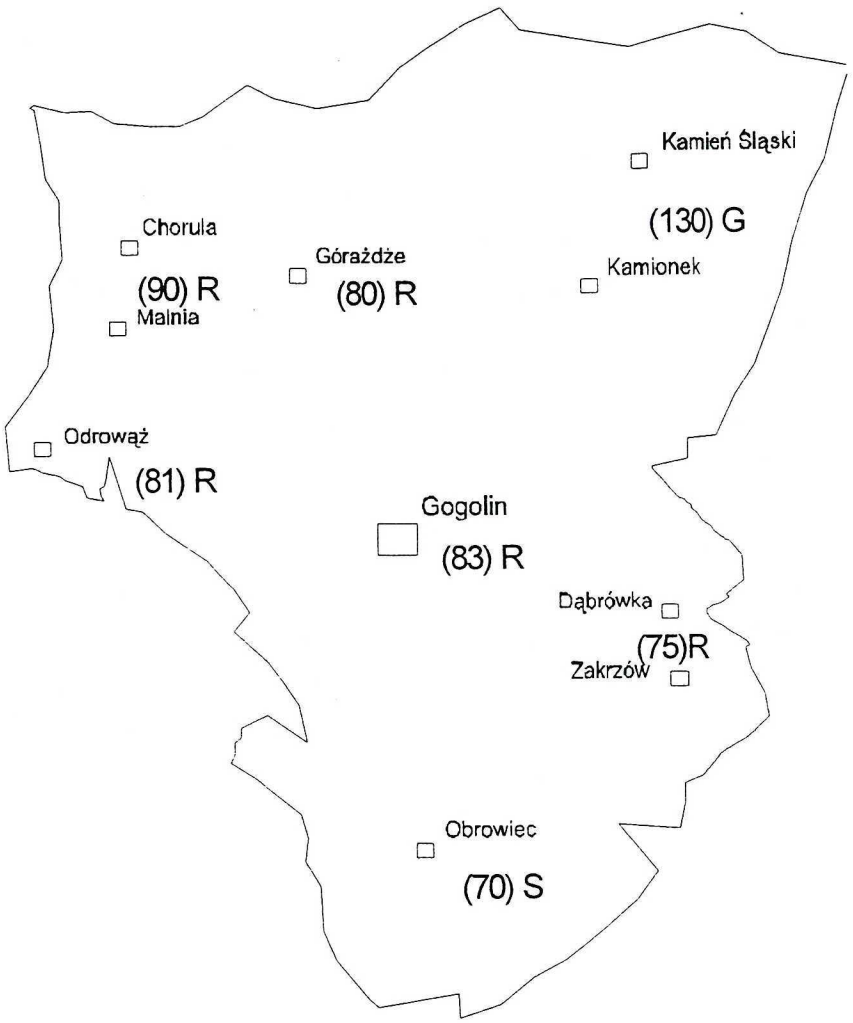

Fig. 1. Localization of towns with the sampling points in the area of Gogolin commune: (81) — depth of the well; water-bearing level: R — ret, S — lower and middle sandstone, G — Gogolin layers

Lokalizacja miejscowości na obszarze gminy Gogolin, w których pobierano próbki: (81) — głębokość studni; poziom wodonośny: R — ret, S — dolnego i środkowego piaskowca, G — warstw gogolińskich

dissolved solids, chloride, sulphate, ammonium, nitrite, nitrate, permanganate index, chromium, zinc, cadmium, manganese, copper, nickel and iron [7]. List of analytical methods applied for the measurements of each variable values is presented hereunder:

Parameter	Method
pH	potentiometric
electrical conductivity	conductometric

hardness	complexometric titration with EDTA
dissolved solids	gravimetric
chloride	Mohr's (argentometric titration)
sulphate	gravimetric
ammonium	Nesslerization
nitrite	colorimetric with 1-naphtylamine and sulphanilic acid
nitrate	colorimetric with sodium salicylate
permanganate index	potassium permanganate
heavy metals	flame atomic absorption spectrometry

The results of the selected physical-chemical parameters were used for estimation of purity of ground waters providing the water-supply system in the whole area of Gogolin commune. The estimation was done on the basis of the conditions to be fulfiled for drinking water and water for household purposes, and criteria concerning classification of ordinary ground waters for environmental monitoring purposes [1, 3].

RESULTS AND DISCUSSION

Results of analyses of water samples from the water-supply system are compiled in Table 1 – presenting mean and maximum values of ten physical-chemical parameters of water quality, and Table 2 – revealing maximum concentration of seven heavy metals.

Majority of analysed samples met the requirements of Polish Standards concerning drinking and domestic water (Tab. 1). Concentration of hydrogen ions, measured by pH value, was slightly differentiated and varied between 6.5 and 7.5; in particular towns the mean pH value was from 7.0 to 7.3 and the maximum from 7.1 to 7.5. Lowest and highest pH values were defined in water samples collected from the intake in Gogolin. Moreover, the maximum pH 7.5 was detected in water taken in Kamionek. Total hardness of water ranged from 167 mg $CaCO_3/dm^3$ (Gogolin) to 350 mg $CaCO_3/dm^3$ (Zakrzów) on average. Considering hardness, water in the commune area is qualified as mean hard, with exception for Gogolin where the indicator value characterizes water as soft. Water samples from Gogolin intake were characterized by the lowest value of electrical conductivity (mean 325 μS/cm, max. 373 μS/cm). In other towns, except Dąbrówka and Zakrzów, water always revealed electrical conductivity over 500 μS/cm, with the mean value from 603 (Odrowąż) to 759 μS/cm (Obrowiec).

The lowest content of dissolved solids, chloride and sulphate was also determined in water samples collected from Gogolin intake. The maximum concentration of dissolved solids was 186 mg/dm^3, while in the other towns exceeded 300 mg/dm^3 (except the intake in Dąbrówka – max. 254 mg/dm^3). The content of chlorine ions was low in all analysed samples; mean values ranged 6.3 – 38.1 mg/dm^3 and max. varied between 9.5 (Gogolin) and 42.2 mg/dm^3

Table 1. Mean and maximum values of the chosen physical-chemical parameters of waters from the water-supply system of Gogolin commune
Średnie i maksymalne wartości wybranych parametrów fizyczno-chemicznych w wodzie pobranej z systemu wodociągowego gminy Gogolin

Parameter Wskaźnik	Value range Zakres wartości	Water intake/Ujęcie wody										Permitted values* Wartości dopuszczalne*
		Chorula	Dąbrówka	Gogolin	Górażdże	Kamień Śl.	Kamionek	Malnia	Obrowiec	Odrowąż	Zakrzów	
[pH] Odczyn	mean średnia	7.3	7.3	7.2	7.2	7.2	7.2	7.2	7.0	7.2	7.1	6.5–8.5
	max	7.4	7.3	7.5	7.4	7.4	7.5	7.3	7.1	7.2	7.2	
Electrical conductivity Przewodność elektrol. [μS/cm]	mean średnia	714	458	325	656	728	673	697	759	603	500	–
	max	766	508	373	690	773	708	769	850	709	610	
Dissolved solids Substancje rozp. [mg/dm^3]	mean średnia	371	207	173	325	373	321	369	405	343	242	800
	max	385	254	186	339	388	353	385	422	357	305	
Hardness Twardość [mg $CaCO_3$/dm^3]	mean średnia	290	210	167	301	300	252	217	336	261	350	500
	max	330	224	190	346	328	276	233	348	286	384	
Chlorides Chlorki [mg Cl/dm^3]	mean średnia	21.9	11.8	6.3	20.8	9.9	9.7	21.1	38.1	27.4	29.6	300
	max	26.7	15.4	9.5	24.0	10.7	10.1	25.9	42.2	30.7	38.4	
Sulphates Siarczany [mg SO_4/dm^3]	mean średnia	123.0	16.5	15.7	107.0	181.0	164.0	119.3	115.2	55.3	65.8	200
	max	135.8	28.8	20.6	140.0	238.6	193.4	135.8	152.2	74.0	78.2	
Ammonia nitrogen Azot amonowy [mg N–NH_4/dm^3]	mean średnia	n.w.	0.01	0.01	n.w.	n.w.	n.w.	n.w.	0.01	0.01	0.01	0.5
	max	n.w.	0.02	0.02	n.w.	n.w.	n.w.	n.w.	0.3	0.02	0.03	
Nitrite nitrogen Azot azotynowy [mg N–NO_2/dm^3]	mean średnia	0.001	0.002	0.002	0.002	0.001	0.001	0.002	0.003	0.002	0.002	–
	max	0.004	0.005	0.007	0.005	0.002	0.002	0.006	0.012	0.005	0.008	
Nitrate nitrogen Azot azotanowy mg N–NO_3/dm^3]	mean średnia	7.0	4.0	0.2	3.7	0.7	0.7	6.4	7.9	5.1	4.4	10.0
	max	12.0	7.2	0.5	7.0	0.9	0.8	8.5	15.0	9.7	7.2	
Permanganate index $ChZT_{Mn}$ [mg O_2/dm^3]	mean średnia	1.4	1.6	1.1	2.4	1.3	1.4	1.9	2.4	2.6	2.5	–
	max	1.8	1.8	1.9	3.9	1.9	1.8	2.6	3.1	3.4	3.4	

* According to Provision of the Minister of Health and Welfare May 4, 1990

* Według Rozporządzenia Ministra Zdrowia i Opieki Społecznej z dnia 4 maja 1990 r.

(Zakrzów), whereas big differentiation among samples was noted for sulphate concentration. Sulphate content varied between min. 8.2 mg/dm^3 (Gogolin) and max. 238.6 mg/dm^3 (Kamień Śląski), determining the mean value for particular intakes within the range of 15.7–181.0 mg/dm^3. At the same time, the maximum sulphate concentration detected in water taken in July 1996 from Kamień Śląski intake exceeded the limit value by 38.6 mg/dm^3.

The amount of nitrogen compounds in water was also considerably differentiated. Ammonia nitrogen was not detected in samples collected from water intakes of Chorula, Górażdże, Kamień Śląski, Kamionek and Malnia, i.e. in 50% of the researched towns. Whereas in others – Dąbrówka, Gogolin, Obrowiec, Odrowąż, Zakrzów – ammonia nitrogen concentrations varied from trace amounts to 0.3 mg/dm^3 (Obrowiec), determining the identical mean value of 0.01 mg/dm^3 for all these towns. Nitrite nitrogen was usually present in water in trace amounts, occasionally exceeding value of 0.003 mg/dm^3; with the exception of Obrowiec intake where the highest mean concentration (0.003 mg/dm^3) and maximum one (0.012 mg/dm^3) were noted. The largest difference among analysed water samples concerned nitrate nitrogen amounts, as its mean concentrations varied between 0.2 and 7.9 mg/dm^3 and maximum ones ranged from 0.5 (Gogolin) to 15.0 mg/dm^3 (Obrowiec). In the case of two intakes (water samples collected in August 1996), exceeding of the permitted value by 5.0 and 2.0 mg/dm^3 respectively, in Obrowiec and Chorula was registered.

The analysis of heavy metal content revealed no significant difference among particular water intakes, especially for chrome, copper, nickel and cadmium (Tab. 2). Heavy metal concentrations – except iron in water samples of Górażdże intake – were always below permitted values; however, the water of Gogolin intake had the max. manganese concentration equal to the limit value. Iron content in the water in Górażdże intake varied between 0.150 and 1.025 mg/dm^3 exceeding twice the limit value (0.5 mg/dm^3) set for drinking and domestic water according to Polish Standards.

Having compared the results obtained within the limit values applied in the classification of ground waters for environmental monitoring purposes (Tab. 3), it can be concluded that values of most of parameters corresponded with waters of the highest (Ia) and high (Ib) quality (Fig. 2). The decrease in the water quality to the average class (II) is connected with increased electrical conductivity of waters almost in the whole area of Gogolin commune, as well as with an augmentation in sulphate and iron content which occurred occasionally and locally. Values of these quality parameters reflect both properties of supplied Triassic waters (hydrogen carbonate – sulphate waters of significant degree of mineralization) [5], and possibilities of water quality changes under the influence of anthropopression. Increased iron and manganese content may, in great measure, be a consequence of strong disturbances in chemical com-

Table 2. The maximum trace element content [mg/dm^3] in waters from the water-supply system of Gogolin commune
Maksymalna zawartość metali ciężkich [mg/dm^3] w wodzie z ujęć sieci wodociągowej na obszarze gminy Gogolin

Parameter Wskaźnik	Permitted concentration Stężenie dopuszczalne	Water intake Ujęcie wody									
		Chorula	Dąbrówka	Gogolin	Górażdże	Kamień Śl.	Kamionek	Malnia	Obrowiec	Odrowąż	Zakrzów
Chromium Chrom	0.01	0.006	0.002	0.008	0.008	0.008	0.007	0.006	0.006	0.004	0.007
Zinc Cynk	5.0	0.120	0.380	0.040	0.400	0.140	0.090	0.060	0.600	0.400	0.490
Cadmium Kadm	0.005	0.004	0.003	0.003	0.004	0.003	0.003	0.003	0.004	0.004	0.004
Manganese Mangan	0.1	0.021	0.016	0.100	0.067	0.043	0.020	0.067	0.030	0.009	0.065
Copper Miedź	0.05	0.010	0.013	0.009	0.014	0.012	0.012	0.013	0.011	0.016	0016
Nickel Nikiel	0.03	0.018	0.012	0.009	0.010	0.012	0.012	0.008	0.007	0.008	0.014
Iron Żelazo	0.5	0.035	0.049	0.301	1.025	0.185	0.089	0.134	0.059	0.047	0.053

Table 3. Classification of ordinary ground waters in the State Environmental Monitoring
Klasyfikacja zwykłych wód podziemnych w Państwowym Monitoringu Środowiska

Parameter Wskaźnik	Water quality class/Klasa jakości wód			
	Ia	Ib	II	III
pH Odczyn	6.5–8.5	6.5–8.5	< 6.5 or > 8.5	< 5.0 or > 9.0
Dissolved solids/Subst. rozp. [mg/dm^3]	500	800	1000	2000
Electrical conductivity Przewodnictwo właściwe μS/cm	300	400	800	1000
Hardness/Twardość [mg $CaCO_3$/dm^3]	150–300	300–500	500–750	>750
Chlorides/Chlorki [mg Cl/dm^3]	60	200	300	600
Sulphates/Siarczany [mg SO_4/dm^3]	60	200	300	600
Permanganate index/Utlenialność [mg O_2/dm^3]	2.5	5.0	10	20
Ammonia nitrogen/Azot amonowy [mg N–NH_4/dm^3]	0.1	0.5	1.0	1.5
Nitrate nitrogen/Azot azotanowy [mg N–NO_3/dm^3]	1.0	10	10	50
Nitrite nitrogen/Azot azotynowy [mgN–NO_2/dm^3]	0	0.02	0.03	0.1
Chromium/Chrom [mg Cr/dm^3]	0.005	0.01	0.05	0.1
Zinc/Cynk [mg Zn/dm^3]	0.5	5.0	10.0	10.0
Cadmium/Kadm [mg Cd/dm^3]	0.001	0.005	0.005	0.005
Copper/Miedź [mg Cu/dm^3]	0.01	0.05	0.5	1.0
Manganese/Mangan [mg Mn/dm^3]	0.05	0.1	0.4	1.0
Nickel/Nikiel [mg Ni/dm^3]	0.01	0.03	0.1	0.1
Iron/Żelazo [mg Fe/dm^3]	0.1	0.5	3.0	5.0

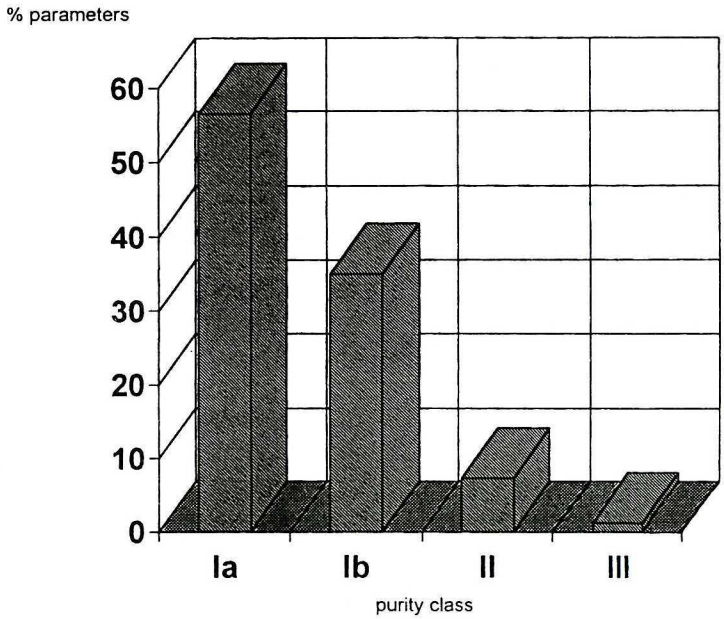

Fig. 2. Percentage share of physical-chemical parameters in the particular classes of water purity in the area of Gogolin commune

Procentowy udział parametrów fizyczno-chemicznych w poszczególnych klasach czystości wód na obszarze gminy Gogolin

position of water. The disturbances result from big fluctuations of a static water-level, which occur during exploitation works in opencast mining since the commune of Gogolin is situated within the range of Opole District of the Carbonates Raw Materials Exploitation [6]. Exploitation works also exert an influence on sulphate content in water. Increased sulphate concentration may result from geogenic pollution owing to changes of ground water flow directions and penetration of waters from the ground of higher mineralization. The reason for this process are lower values of piezometric pressure around water intakes and opencast mining [2]. Moreover, during the study, water samples collected from Obrowiec and Chorula intakes were twice numbered in class III, i.e. waters of low quality, considering increased concentration of nitrate nitrogen. It can be suspected that the reason for water pollution with nitrate in these towns is an excessive enrichment of soils with nitrogen compounds as a result of intensive fertilization and the presence of animal farms. Then, nitrogen compounds are rinsed deep into the soil profile from where they penetrate into the water-bearing horizon.

CONCLUSIONS

1. The results of the study indicate generally good quality of ground waters distributed through the water-supply system within the area of Gogolin commune.

2. The exceeding of the limit values for drinking and household waters occurred occasionally and was noted for three physical-chemical parameters:
- nitrate nitrogen – by 50% in Obrowiec and 20% in Chorula,
- sulphate – by 19% in Kamień Śląski,
- iron – by 100% in Górażdże.

3. Localization of towns, where the changes in physical-chemical composition of derived ground waters occurred, indicate possibilities of the negative anthropogenic influence (opencast mining, farming) on the ground water quality.

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