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# THE QUALITY OF WELL WATERS IN POLAND – A STUDY CASE

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ABSTRACT: The aim of this study was to analyse the quality and compare the functional value of water from traditionally dug and drilled wells located in western Poland. Basic physicochemical and microbiological (Escherichia coli in 100 ml, coliform bacteria in 100 ml, enterococci in 100 ml, total number of bacteria in 1 ml grown at 22°C, total number of bacteria in 1 ml grown at 36°C) were determined for the water samples. Additionally, some water samples were analysed for the presence of heavy metals, TN (total nitrogen), TOC (total organic carbon) and NPOC (dissolved organic carbon). The conducted research has indicated that mineral and microbiological contamination occurs in the waters collected from the wells. This confirms that the wells were not sufficiently protected and that penetration of pollutants into the water occurs from their immediate surroundings, geological layers with which underground water resources come into contact.

KEYWORDS: drilled well, dug well, water quality, water pollutants, quality of water

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## Introduction

Groundwater is a very valuable water resource all over the world, including in Poland. It results from the penetration of surface water, mainly rainwater, through the soil layers. During ground filtration, the rainwater encounters impermeable layers such as clay or loam. This causes the voids to be filled with water, thus creating saturation zones (the so-called aquifers) at different depths. After penetration through the ground layers, water becomes purified as the physicochemical and bacteriological pollutants are eliminated to some extent. The quality of the water is determined by the depth at which the aquifer is situated. In terms of sanitation and geology, groundwater aquifers have been divided into shallow, ground, principal, and deep.

Shallow groundwater aquifers are located in shallow ground and are often referred to as near-surface waters. Their depth of deposition varies from a few to several dozen centimetres, more rarely to several meters, e.g. in depressions of the terrain. They are separated from the land surface by a layer of soil and ground characterised by small thickness, and they mainly result from precipitation. These waters are usually used by plant root systems. Due to their short contact with the ground layers during filtration, these waters are not sufficiently purified and are susceptible to daily temperature fluctuations. Due to the low quality of these waters it is not possible to use them for drinking or in water supply systems.

Groundwater at the ground level occurs above the first impermeable layer and lies at a depth of up to several meters. The groundwater level is related to, inter alia, the type of soil, its porosity and hydrological conditions. In sandy soils, the groundwater level is lower than in soils with high water absorption. Precipitation is the main source of groundwater supply. Therefore, it can often be said that groundwater is filtered rainwater. These types of water are usually highly purified, have a constant temperature, and can be used for consumption, but it is necessary to monitor their quality.

Principal groundwater aquifers occur under hydrostatic pressure and are usually located at depths below several meters, between two impermeable layers. They are characterised by very stable parameters, such as temperature and physicochemical composition. In most cases, well water can be used for drinking purposes, provided that the chemical composition meets the sanitary requirements (Cierniak et al., 2020; Hermanowicz et al., 1999; Rodrigues-Narvaez et al., 2017; Romero et al., 2014; Jha et al., 2020; El Baba et al., 2020; Mohamed et al., 2019; Kapembo et al., 2022; Abbasnia et al., 2019).

Deep waters are the deepest water resources from ancient geological layers. They are highly mineralised and occur deeply between impermeable layers of soil. They are also referred to as relict waters. They are non-renew-

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able. They are often heated by the heat from the Earth's interior and form the so-called thermal water.

Groundwater resources can also be divided into natural, artificial, variable, static, dynamic and operational. According to the literature, exploitable resources include some static or dynamic resources, the exploitation of which does not yield negative effects (Sadurski et al., 2016). According to the data of the Central Statistical Office, exploitation resources of groundwater in Poland in 2020 amounted to 18,439.5 hm$^3$, and the second place in the country in terms of groundwater exploitation belonged to the Greater Poland Voivodship (in west Poland) (Figure 1). In this area, exploitation resources amounted to 1724.9 hm$^3$, which constituted 9.40% of Poland's resources (GUS, 2020a; GUS, 2020b; Ober et al., 2021).

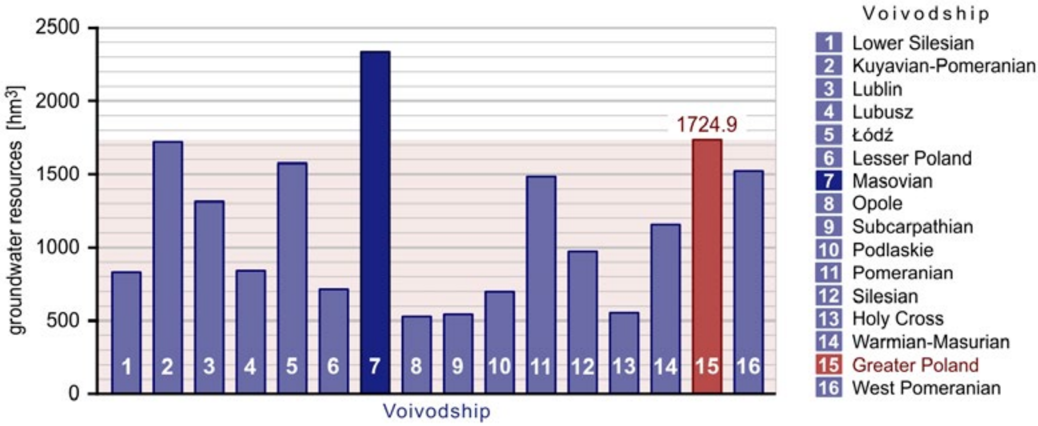


**Figure 1**. Exploitable groundwater resources in Poland in 2020
Source: GUS (2021).

In Greater Poland Voivodship, usable groundwater occurs in the Quaternary, Tertiary, Cretaceous and older formations. The distribution of exploitation resources in geological formations is as follows:

The example of a bulleted list:

- Quaternary – 1031.3 hm$^3$, which accounts for 59.80% of all Greater Poland Voivodship resources,
- Tertiary – 428.9 hm$^3$, which accounts for 24.87% of all Greater Poland Voivodship resources,
- Cretaceous – 235.4 hm$^3$, which accounts for 13.65% of all Greater Poland Voivodship resources,
- older formations – 29.4 hm$^3$, which accounts for 1.70% of all Greater Poland Voivodship resources (GUS, 2021).

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The data indicates that the waters taken for exploitation in Greater Poland Voivodship mainly originate from Quaternary deposits. There are four main groundwater reservoirs in the vicinity of Poznań (Figure 2):

- GZWP 144 – The Greater Poland fossil valley in the Quaternary formations,
- GZWP 143 – Inowrocław Sub-reservoir – Gniezno in older works,
- GZWP 145 – The Szamotuły fossil valley – Duszniki in the Quaternary formations,
- GZWP 150 – Warsaw – Berlin Urstromtal in Quaternary works (Olejniczak et al., 2021).

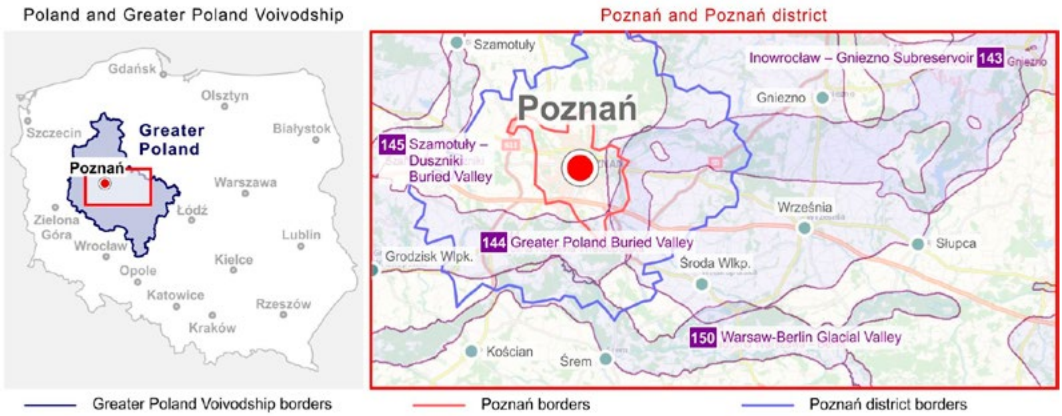


**Figure 2.** Location of the main groundwater reservoirs in the Poznań district

Source: PSH (2021).

According to the data of the Central Statistical Office in the Poznań district, 96.1% of the population used the water supply network in 2020. Furthermore, 96.7% of the urban population drew water from the water supply system. In the case of rural residents, this percentage was equal to 95.8% (GUS, 2020a; GUS, 2020b). This indicates that 3.3% of the urban population and 4.2% of the rural population did not use the water supply system.

Despite the constant development of water supply systems, a part of society has limited access to this infrastructure. The inability to use the water supply system is associated with the need to build a personal water intake. Sometimes the desire to possess a personal water intake is dictated by other reasons, e.g. economic or independence from system solutions (MacDonald Gibson & Pieper, 2017).

Domestic water intakes include driven, dug or drilled wells. Selection of the proper well for a plot of land depends on the depth of the aquifer, geological conditions and construction costs (Jha et al., 2020; El Baba et al., 2020;

Mohamed et al., 2019; Kapembo et al., 2022; Abbasnia et al., 2019; Michałkiewicz et al., 2014).

An Abyssinian well is an example of a well with a punch-in filter. It is designed to collect water from the shallowest aquifer. Usually, its depth is in the range of 3-7 m. The diameter of the driven well does not exceed 50 mm. It is used in sandy soil by driving a pipe with a filter ended with a cone. The well also consists of a concrete ring and a pump with a lowered plunger (usually with a hand lever). The water is extracted from the well while pumping with a hand lever. This causes the piston to move, and hence, the lifting of the water column occurs. The wells with appropriate filters can also be equipped with electric pumps. The Abyssinian well has a low capacity and is not able to provide water for a household. It is most often used for supplying the garden with water (Piekarek, 2006).

Dug (shaft) wells are created by lowering the shaft vertically and then extracting the ground from its interior. These types of wells are most often used for shallow aquifers. It should be noted that the first aquifers are usually not covered with impermeable layers. This has a large impact on the quality of well water, as it is exposed to anthropogenic pollution. The depth of the dug wells ranges from 5 to 20 m. In order to construct the well, in most cases, concrete and reinforced concrete rings with a height of 0.6-1.0 m are used, which should be tightly connected (Piekarek, 2006; Betonbest, 2022). On the other hand, the internal diameters are 0.80-1.2 m. However, it is recommended to build wells with a diameter that exceeds 1.0 m because its capacity and efficiency increase. This also facilitates construction works (Przewłocki et al., 1966). Shaft wells consist of an underground and an above-ground part. The underground part consists of a filter, an impermeable wall and a bottom which can be tight or open. Traditional dug wells include gravel or a perforated mesh at the bottom. On the other hand, the above-ground part is formed by the body of the well and the cover with the hatch that closes it. In this type of wells, the last circle is usually above ground level. It should be noted that the above-ground part must be protected against the inflow of rainwater. Water can enter the well through openings in the side wall or through the bottom (Gabryszewski & Wieczysty, 1985). Water from the dug well is collected by means of a winch, crane, suction pump and hydrophore or by means of a column pump located on the cover (Piekarek, 2006).

Drilled (deep, tubular) wells are a borehole that allows to extract water from aquifers. For technical reasons, the casing is required. These types of wells capture water from greater depths than dug or well-filtered wells. However, for financial reasons, drilled wells with a depth not exceeding 30 meters are the most common (Gabryszewski & Wieczysty, 1985). The water-bearing layers lie under the impermeable layers of the ground, which improves the water quality. Drilled wells may possess small diameters, con-

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ventionally up to 0.3 m, and more rarely larger, exceeding 0.5 m. Filter and non-filter wells can be distinguished. In the case of filter wells, they are formed by casing columns (casing pipe) and a filter column. The casing column consists of joined steel pipes whose main purpose is to protect the walls of the borehole. In addition, it can also form a maintenance column for draining water.

Drilled wells, similar to dug wells, can draw water through the side walls and through the bottom. The construction of a well depends, e.g. on the method of drilling, depth, purpose, hydrogeological conditions and the method of drawing water (Gabryszewski & Wieczysty, 1985). In most cases, a submersible pressure pump or pumps submerged below the water level are installed at the bottom of the well to draw water. It is also worth noting that they are currently the best solution for households (Piekarek, 2006).

## Research methods

In order to assess the quality of water from individual water intakes, 10 dug and drilled wells located in urban and rural areas of the Greater Poland Voivodship were tested. Basic physicochemical (colour, turbidity, content of ammonium nitrogen, nitrite nitrogen, nitrate nitrogen, iron, manganese, orthophosphates, P-general, sulphates, pH, conductivity, alkalinity towards methyl orange, hardness, calcium, chlorides) and microbiological (*Escherichia coli* in 100 ml, coliform bacteria in 100 ml, enterococci in 100 ml, total number of bacteria in 1 ml grown at 22 °C, total number of bacteria in 1 ml grown at 36°C) determinations were carried out for the collected water samples. Additionally, some waters samples were analysed in terms of the presence of heavy metals (chromium, zinc, cadmium, copper, nickel, lead), TN (total nitrogen), TOC (total organic carbon) and NPOC (dissolved organic carbon). The collection of water samples as well as the physic-chemical and microbiological analysis were carried out in accordance with the applicable methodology according to the guidelines of Standard Methods and Polish Standards (Regulation, 2017). Heavy metals were determined using the AA-7000 Shimadzu atomic absorption spectrometer, and the TOC/TN 3100 multi Analytik Jena analyser was used for carbon and nitrogen determinations. The catalytic oxidation via the combustion process is used for the determination of TOC/TN. This method enables the efficient oxidation of recalcitrant organic compounds with low molecular weight but also high-molecular, insoluble and difficult-to-decompose compounds. Nitrogen adapter – TN – enables total nitrogen determination due to thermal decomposition and chemiluminescence.

The characteristics of the studied wells are summarised in Table 1.

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**Table 1.** List of studied wells

| Well number | Location | Well type | Deep | Method of use | |
|---|---|---|---|---|---|
| | | | | watering the garden | to drink |
| 1 | Municipality Kuślin | drilled. deep | 80.0 m | yes | yes |
| 2 | Poznań | drilled | 6.0 m | yes | yes |
| 3 | Kostrzyn Wlkp. | dug | 4.0 m | yes | yes/no |
| 4 | Paczkowo | dug | 3.5 m | yes | yes/no |
| 5 | Rogalin | dug | 8.5 m | yes | yes/no |
| 6 | Jaryszki | drilled | 7.5 m | yes | yes |
| 7 | Zborowo | dug | 6.5 m | yes | yes/no |
| 8 | Borowo | drilled | 26.0 m | yes | yes/no |
| 9 | Puszczykowo | drilled | 17.0 m | yes | yes |
| 10 | Kórnik | dug | 5.5 m | yes | yes/no |

## Results of the research

**Table 2.** Results of physicochemical and bacteriological tests of water from wells No. 1-10

| Water parameter | Unit | Well number | | | | | | | | | | Limit value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| physicochemical tests | | | | | | | | | | | | |
| Colour | mg Pt/l | 10 | 15 | 5 | 10 | 10 | 3 | 5 | 30 | 3 | 4 | accept. to 15 |
| Turbidity | NTU | 1.26 | 5.84 | 1.67 | 3.56 | 2.69 | 1.00 | 0.25 | 15 | 1.00 | 1.20 | accept. to 1 |
| pH | — | 6.93 | 6.61 | 7.04 | 7.15 | 7.13 | 8.20 | 7.75 | 7.14 | 7.01 | 6.97 | 6.5÷9.5 |
| Electrical conductivity (EC) | µS/cm | 1145 | 1253 | 1594 | 809 | 1528 | 676 | 573 | 680 | 662 | 483 | 2500 |
| Ammonium nitrogen | mg $NH_4$/l | 0.348 | 0.888 | 0.315 | 0.287 | 0.464 | 0.140 | 0.001 | 1.220 | 0.232 | 0.106 | 0.5 |
| Nitrite nitrogen | mg $NO_2$/l | 0 | 0.098 | 0.011 | 0 | 0 | 0.024 | 0.011 | 0.013 | 0.019 | 0 | 0.5 |
| Nitrate nitrogen | mg $NO_3$/l | 0.032 | 3.042 | 2.348 | 5.010 | 0.044 | 0.127 | 0.111 | 0.431 | 0.324 | 0.166 | 50 |
| Iron | mg Fe/l | 0.021 | 0.091 | 0.009 | 0.032 | 2.207 | 0.090 | 0.140 | 2.452 | 0.072 | 0.198 | 0.2 |
| Manganese | mg Mn/l | 0.273 | 1.474 | 0 | 0 | 0.423 | 0 | 0 | 0.008 | 0 | 0.070 | 0.05 |
| Orthophosphates | mg P/l | 0 | 0.502 | 0.492 | 0.081 | 0.098 | 0.065 | 0.124 | NS | 0.058 | 0.164 | — |
| P-general | mg P/l | 0.091 | 0.917 | 0.746 | 0.142 | 0.247 | 0.120 | 0.180 | NS | 0.124 | 0.197 | — |
| Sulphates | mg $SO_4$/l | 215.16 | 96.68 | 70.35 | 83.92 | 102.43 | 87.92 | 182.22 | 104.76 | NS | 127.13 | 250 |
| Methyl orange alkalinity | mval/l | 5.10 | 7.95 | 8.30 | 5.85 | 6.50 | 7.30 | 8.00 | 8.50 | 7.00 | 4.70 | — |
| Total hardness | mg $CaCO_3$/l | 607.0 | 606.0 | 439.0 | 488.5 | 760.5 | 455.5 | 310.5 | 341.0 | 421.5 | 241.0 | 60÷500 |
| Calcium | mg Ca/l | 173.91 | 175.13 | 117.58 | 138.67 | 224.45 | 127.23 | 67.91 | 92.92 | 132.24 | 80.77 | — |
| Magnesium | mg Mg/l | 42.03 | 40.98 | 35.33 | 34.55 | 48.68 | 33.46 | 34.33 | 26.51 | 22.17 | 9.56 | 7÷125 |
| Chlorides | mg Cl/l | 103.5 | 133.0 | 210.0 | 32.0 | 63.0 | 76.0 | 44.0 | 40.0 | 85.0 | 17.0 | 250 |
| bacteriological tests | | | | | | | | | | | | |
| *Escherichia coli* | jtk/100 ml | 0 | 0 | 6 | 5 | 0 | 0 | 50 | 0 | 0 | 0 | 0 |
| Coliforms bacteria | jtk/100 ml | 47 | 6 | 36 | 34 | 13 | 0 | 200 | 0 | 0 | 16 | 0 |
| Enterococci | jtk/100 ml | 0 | 0 | 16 | 31 | 1 | 0 | 12 | 0 | 0 | 0 | 0 |
| Bacteria grown at 22°C | jtk/1 ml | 42 | 620 | 6400 | 3200 | 3900 | 12 | 11 | 45 | 2 | 310 | 100 NA |
| Bacteria grown at 36°C | jtk/1 ml | 16 | 105 | 5650 | 300 | 1850 | 5 | 65 | 12 | 3 | 10 | — |

*limit values exceeded*

*wells that meet all the requirements contained in the Regulation of the Minister of Health (Dz. U. 2017. poz. 2294)*

accept. - *acceptable*
NS - *not studied*
NA - *no abnormal changes*

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The results of physicochemical and bacteriological testing of water and the permissible values of individual parameters in accordance with the Regulation of the Minister of Health on the quality of water intended for human consumption, which is in force in Poland (Regulation, 2017) were presented in Table 2. Moreover, the results of heavy metals, TOC, TN and NPOC determinations in selected wells were presented in Table 3.

**Table 3.** Results of heavy metals, TOC, TN and NPOC determinations in selected wells

| Water Parameter | Unit | Well number | | | | Limit value |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | |
| Chromium | mg Cr/l | 0.0955 | 0.1121 | 0.1427 | 0.1546 | 0.05 |
| Zinc | mg Zn/l | 0 | 0.0500 | 0.0574 | 0.1090 | — |
| Cadmium | mg Cd/l | 0.0032 | 0.0046 | 0.0065 | 0.0082 | 0.005 |
| Copper | mg Cu/l | 0.0070 | 0.0111 | 0.0145 | 0.0193 | 2.0 |
| Nickel | mg Ni/l | 0.0128 | 0.0098 | 0.0098 | 0.0118 | 0.02 |
| Lead | mg Pb/l | 0.0253 | 0.0678 | 0.0578 | 0.0632 | 0.01 |
| TOC | mg C/l | 0 | 0 | 0 | 0 | — |
| TN | mg N/l | 0.6304 | 5.3 | 12.87 | 10.84 | — |
| NPOC | mg C/l | 2.92 | 7.04 | 4.89 | 3.17 | — |

*limit values exceeded*

## Discussion

The quality of water from individual intakes is often not subjected to periodic monitoring, as is the case with waterworks. As a consequence, inadequately treated and disinfected water can be dangerous to human health and even life. Moreover, numerous physicochemical and microbiological contaminants in the water render it impossible to use, e.g. for drinking purposes (MacDonald Gibson & Pieper, 2017; Kowalski et al., 2017; Mahmoud et al., 2022; Ximenes et al., 2018).

Excessive turbidity of water collected from most wells may be associated with the presence of suspensions of mineral or organic origin (Kiedryńska et al., 2006). In addition, water hardness can also cause turbidity due to the precipitation of calcium and magnesium carbonate (Water Engineering, 2022). In three wells, the water was very hard (+500 mg $CaCO_3$/l) and exceeded the permissible values specified in the Regulation of the Minister of Health. The high hardness of the analysed well waters indicates the presence of dissolved substances, mainly calcium and magnesium salts (Water Engineering, 2022). Calcium had a significant contribution to the observed hardness, as its concentrations ranged from 67.91 to 224.45 mg Ca/l, while the magnesium concentrations remained at the lower levels, from 9.56 to 48.68 mg Mg/l. Water samples from four wells (no. 1, 2, 5, 10) were characterised by exceeding the manganese content. This may indicate the penetration of this element into groundwater from plant debris or soil, leaching from the ground, and contamination with wastewater (Kiedryńska et al., 2006). The situation was notably better in terms of the presence of iron in the water because the permissible value of this element was exceeded only in two wells.

After analysing the bacteriological status of the well water, it can be concluded that typical indicator bacteria (*Escherichia coli*, coliform bacteria or enterococci) were not detected only in three wells, while the number of bacteria grown at 22°C in five wells was low (below 100 CFU/1 ml). In four wells, the number of bacteria grown at 36°C exceeded 100 CFU/1 ml. The content of mesophilic bacteria in water (cultivation at 36°C) may result from pollutants such as sewage, soil and vegetation, and psychrophilic bacteria (cultivation at 22°C) from the presence of organic substances in water. The presence of coliforms, *Escherichia coli* and enterococci in water is particularly dangerous for human health, as it indicates contamination of the wells with human or animal faeces, and thus the potential possibility of the presence of other but pathogenic bacteria, e.g. *Salmonella, Shigella, Klebsiella, Clostridium, Campylobacter* (Ciślak & Michałkiewicz, 2021). It can be assumed that the microbiological contamination of well water results from the improper location of the wells in the field and failure to comply with the requirements of the Minister of Infrastructure (Regulation, 2019).

In accordance with the regulations in force in Poland, contained in the Journal of Laws 2019, item 1065, the distance of the well-supplying water intended for human consumption should be – from the axis of the well – at least: 5 m to the plot border, 7.5 m to the axis of the roadside ditch, 15 m to livestock buildings and related airtight silos, waste collection tanks, compost and similar sealed devices, 30 m to the nearest drainage conduit of an individual sewage system, if biologically treated sewage is discharged into it to the extent specified in the provisions on water protection, 70 m to unpaved enclosures for livestock, to the nearest infiltration pipe of the local sewage system without biological sewage treatment devices and to the border of the filtration field. In addition, the area surrounding the dug well and the drilled well pipe, in a strip at least 1 m wide, counting from the outer casing of the well, should be covered with a hardened surface with a 2% slope towards the outside. In the case of the analysed wells, it was found that the above regulations are often not followed.

Analysis of the results of heavy metal determinations indicated that the permissible values of chromium, cadmium and lead were exceeded. Excessive concentrations of chromium in water samples may indicate water contamination with wastewater that may contain chromium compounds. On the other hand, increased cadmium content indicates that the water had contact with industrial sewage or soil fertilised with phosphorus fertilisers. The

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presence of lead in groundwater can originate from the leaching of soil containing lead compounds, from pollutants supplied with industrial wastewater, or it can be introduced into the water due to corrosion of lead pipes or tanks coated with lead compounds and from car exhaust fumes. The highest lead content was found in water from a drilled well located in Poznań. It should be remembered that the vast majority of heavy metals are toxic substances that act as carcinogens and have a negative impact on human health (Ciślak & Michałkiewicz, 2021).

The elevated content of ammonia nitrogen in groundwater may indicate that the water is contaminated with domestic or industrial wastewater. The concentrations of ammonia nitrogen in the tested water samples varied, but in wells 2 and 8, they exceeded the permissible concentration (0.5 mg $NH_4$/l), reaching the values of 0.888 mg/l (well 2) and 1.220 mg/l (well 8). Taking into account the concentration of nitrite nitrogen, it should be remembered that it is the most unfavourable form of nitrogen compound in groundwater, as it is highly toxic to living organisms. The high content of these compounds indicates that very intense nitrogen transformations occur, most often in hypoxic or anaerobic conditions, i.e. under conditions unfavourable for aerobic organisms (including humans). The concentration of nitrite nitrogen in the waters taken from the selected wells ranged from 0.000 to 0.098 mg/l (in well number 2), and the permissible concentration of 0.5 mg/l was not exceeded in any case. A similar situation was observed when determining the concentration of nitrates (V); the values were not exceeded in all wells.

The results of the TOC tests confirmed that the analysed water samples did not contain any organic substances. This can be explained by the fact that the concentration of organic matter in groundwater decreases significantly over time. This phenomenon is caused by the process of mineralisation of organic compounds, i.e. chemical and biological degradation to carbon dioxide, which can occur due to both aerobic and anaerobic processes. On the other hand, the presence of nitrogen compounds in groundwater is the result of geochemical changes occurring in the aquifer and may also be the result of the presence of anthropogenic pollutants (well 3, TN concentration – 12.87 mg N/l). The main sources of nitrogen compounds, in this case, are probably easily soluble inorganic nitrogen salts, which enter groundwater from improperly secured septic tanks.

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## Conclusions

On the basis of the obtained results of water tests from dug and bored wells, it can be stated that the quality of groundwater, both shallow and deeper, is not satisfactory. Among the deeper wells (over 10 m deep), only the water from well no. 9 meets all the requirements specified in the Regulation of the Minister of Health on the quality of water intended for human consumption, while among the shallow wells (up to 10 m deep) only well no. 6 meets the criteria. In water samples from other wells, it was noted that the physicochemical or bacteriological parameters were exceeded. Therefore, in order to fully use these waters, it is necessary to apply the processes of their treatment and disinfection.

For water treatment in domestic installations, one can use filters with filter cartridges, iron removal, manganese removal and water softening. In order to improve microbiological parameters, one can periodically chlorinate the water in the well or install UV lamps immediately before water intake in a given room (e.g. in the kitchen under the sink). The cost of the investment ranges from 2,000 to 3,000 EUR depending on the devices used. However, if it is not possible to use municipal water supplied by a water company that meets all the criteria contained in the Regulation of the Minister of Health on the quality of water intended for human consumption, such an investment is profitable and gives us a guarantee that we will have a home drinking water.

The periodic water quality control should be very important information for the users of the wells, both in terms of physicochemical and microbiological parameters. In addition, sanitary regulations should be taken into account during the construction of the well, which indicates the location of the wells at appropriate distances from potential sources of contamination (septic tanks, absorbent pits, manure landfills, etc.). Unfortunately, many people who use well water on a daily basis have never commissioned a water test to assess its suitability for consumption. On the other hand, people who use water from the well only for watering the garden most often believe that such a test is unnecessary, which is a misconception, since watering plants with contaminated water, especially in microbiological terms, may result in the transmission of pathogenic microorganisms to the human body.

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## The contribution of the authors

Conceptualization, M.M., I.K. and D.G.K.; literature review, M.Ć, P.M. and W.G.; methodology, M.M.; formal analysis, M.M., I.K., D.G.K. and W.G; writing, M.M., P.M., W.G. and I.K.; conclusions and discussion, M.M., I.K., D.G.K. and M.Ć. Authors have read and agreed to the published version of the manuscript.

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